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A GEARED LOCOMOTIVE, weighing 290,000 lbs., has recently been built for the El Paso & Rock Island R. R., to work on a division 28 miles long, with grades of 3 to 6½%. The engine was built by the Lima Locomotive Works, of Lima, O., and is of the Shay type, with vertical cylinders at one side of the firebox, driving a longitudinal crank shaft. Intermediate shafts, with flexible couplings, transmit motion to shafts on the trucks, these latter shafts having bevel pinions which gear with bevel wheels bolted to the faces of the 40-in. driving wheels. The engine itself has two trucks, but motion is also imparted in a similar way to the two tender trucks. The total wheelbase is 54 ft. 4 ins. The boiler is 5 ft. diameter, and the firebox 54 × 96 ins.; heating surface, 1,990 sq. ft.; grade area, 36 sq. ft. There are three vertical inverted high-pressure cylinders, 15 × 17 ins., fitted with balanced slide valves and the ordinary valve gear. The cranks are set at 120°. The engine has frames of steel I-beams, connected by body bolsters of steel channels. The engine is fitted with a steam brake on all the 16 wheels, and has the Westinghouse train brake. Of course, the greater proportion of the load is carried on the engine trucks, the tender weighing 62,000 lbs. empty and carrying 6,000 gallons of water. The coal is carried in a bunker behind the cab.

TRACK WIDENING ON THE NATIONAL RAILROAD of Mexico, transforming the line from narrow to standard gage, is now in full progress. On June 10 the first section of new track was opened to traffic for the 118 miles between Alice and Laredo, Tex. Work on the next section, or Laredo to Monterey, Mex., is now to be taken in hand, and will be finished before Sept. 1 next. The length of this section is 168 miles. Work is in progress on the El Salto-Soria cut-off, which is to save 40 miles in distance.

HEADINGS MET IN THE ALBULA TUNNEL on May 29, 1902. The Albula Tunnel, in Switzerland, is a short but important section of railway just being built from Thusis, in the Rhine Valley, to St. Moritz, in the Engadine, and forms the means by which this railway crosses the divide (see Engineering News of Dec. 19, 1901). The tunnel (single track) is 5,866 m. (19,241 ft.) long between portals, passing for the greater part through a very hard gneiss rock, so-called Antigorio gneiss. The last progress report to hand, that for April, 1902, showed the headings about 1,000 ft. apart; at that time the finished tunnel (broken out to full section and lined where required) totaled up to 9,450 ft., leaving 9,791 ft. still to be completed. It is expected that the tunnel will be opened for traffic in the course of the present year. Some information as to levels, section, etc., of the Albula Tunnel will be found in the issue of this paper referred to above. We will present a fuller report on the work of construction of this tunnel as soon as the necessary data become available.

THE WHITECHAPEL & BOW LONDON UNDERground Ry., 2¼ miles long, was formally opened for traffic on May 31. This railway leaves the Metropolitan District Ry. at the former Whitechapel terminus, which is now converted into a through station; it then runs as a double track line in a tunnel for 1¾ miles, practically following beneath the Whitechapel Road, Mile End Road and Bow Road. This partion was built almost entirely in open cut and then covered over. The line passes under the Regents Canal in two 18-ft. cast-iron tuber. which are here substituted for the brick arch, owing to a lack of sufficient head room. At its western terminus the "underground" connects with the Tilbury main line. The engineer was Mr. C. A. Brereton, M. Inst. C. E., associated with Sir John Wolfe Barry, M. Inst. C. E. The resident engineer was Mr. Alfred Pearce, M. Inst. C. E.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred on the Central Vermont Ry. near Middlesex, Vt., on June 15. A cloudburst washed out a large section of track and a freight train was ditched in the gap. Five men of the train crew were killed.——On June 12 a southbound fast mail on the Nashville, Chattanooga & St. Louis Ry. collided with a north-bound accommodation train near Chattanooga, Tenn. Four men of the train crew were killed outright and several others perhaps fatally injured. The meeting point for the trains had been changed, as the mail was behind time, and it is thought one of the trains ran past its stop.

A RUNAWAY ELEVATOR injured a number of people in New York city on June 16. The elevator, an old one, was belt-driven, and was intended for both freight and passenger use. Its capacity was about 2,200 to 2,400 lbs. It was located in a loft building at 418 Broome St., in the heart of the wholesale district of the city. At noon-time the employes of a firm of clothing manufacturers occupying the sixth floor crowded on to the elevator, on their way down to the street. Before the car was started running down, it began to slip under its load, and in spite of attempts to stop it, it dropped to the bottom of the pit. Of the 16 persons in the car at the time, all were more or less hurt, but none dangerously. It is said the accident was due to the looseness of the belt, which slipped on its pulley under a load less than the capacity of the elevator. There were no safety devices attached to the elevator.

A PARTIAL FAILURE OF A STONE DAM near Ashland, N. H., occurred on June 8. The dam is on the outlet of Big and Little Squam Lakes, navigable bodies of water. The break appears to have been slight, only 1 ft. in depth and 15 ft. or so in length, but it was feared that the whole structure would be carried out by the prevailing high water. A coffer dam was at once started to prevent a further break.

WATER PURIFICATION WORKS FOR BIRMINGHAM, Ala., are reported as having been decided upon by the Birmingham Water-Works Co. Not long ago the city council passed an ordinance calling upon the company to install a filter plant, having been moved to do so by a report on the water supply made by Mr. Samuel M. Gray, M. Am. Soc. C. E., of Providence, R. I. The local company, which is controlled by the American Water-Works & Guarantee Co., of Pittsburg, Pa., called in Messrs. Geo. H. Benzenberg, M. Am. Soc. C. E., of Milwaukee, and Geo. W. Fuller, Assoc. M. Am. Soc. C. E., of Hering & Fuller, New York city. These gentlemen reported that some of the sources of supply were satisfactory and that others were liable to occasional pollution. It is stated that mechanical filters will be installed.

AN INDEPENDENT FIRE PROTECTION PIPE LINE at St. Louis has been recommended by Mr. Chas. E. Swingley, Chief of the Fire Department.

THE ST. LOUIS EXPOSITION will probably be postponed to 1904. Provision for such postponement is made in a clause of the Sundry Civil Appropriation bill, now pending in Congress, and there is no opposition to the postponement. The clause as now framed provides for holding the dedicatory ceremonies on April 30, 1903, and opening the exposition on May 1, 1904.

OIL FOR FUEL AT THE GALVESTON WATERworks pumping station is an improvement now being introduced. A supply main has been laid across the bay to the island and storage tanks are being put in at the pumping plant.

THE TWENTY-HOUR TRAINS, NEW YORK TO CHIcago, on both the New York Central and Pennsylvania lines, reached Chicago a little ahead of schedule time on June 16. By the Central route the distance is 980 miles. The fastest time on this run was near Pine, Ind., where a mile was made at the rate of about 88 miles per hour. The Central train reached Chicago two minutes ahead of schedule time. The Pennsylvania route from New York to Chicago is 912 miles long, and the train reached the latter point three minutes ahead of the schedule, the average speed for the run being 46½ miles per hour. Each train included four heavy cars, or a sleeper, compartment car, dining car and a cafe-smoker.

THE TERMS OF THE PENNSYLVANIA RAILROAD tunnel franchise, under which that road will gain access to and across New York city, have been agreed upon by the Rapid Transit Commissioners and the company. The compensation for the first 10 and following 15 years has been arranged as follows:

	First 10 years.	Next 15 years.
For river rights	$200	$200
For tunnel rights in Manhattan Borough, being 44,341 ft. (partly estimated) of single track	22,170	44,341
For tunnel rights in Queens Borough, being 8,100 ft. (partly estimated) of single track	2,025	4,050
For street rights in 31st and 33d Sts., north and south of terminal	14,000	28,000
For secondary station at 33d St. and Fourth Ave.	1,140	2,280
For parts of 32d St.	36,000	36,000
Totals each year	$75,535	$114,871

The franchise is to be perpetual, but the compensation is to be readjusted at intervals of 25 years. The company is to buy, as soon as the city can sell, portions of 32d St. for $788,000, and meanwhile is to pay $36,000 a year therefor. The franchise has to be approved by the Board of Aldermen.

AS COMPENSATION FOR PARCELS lost in transmission, the Paris, Lyons & Mediterranean R. R. Co. paid out $1,000,000 in 1901, according to the report of the president of the company at its last annual meeting of shareholders. These parcels were sent by Parcels Post, and in answer to a query the president stated that the five great railway companies having their termini in Paris paid out the aggregate sum of over $5,000,000 for parcels lost in transmission. One shareholder figured that the payment of $1,000,000 represented the loss of about 400,000 parcels in a year, and he very truly remarked that something must be radically wrong with the working of the parcels system. The figures given seem enormous in a country accustomed to American methods of conveying light goods, but the London "Financial Times" is responsible for the statement.

THE SEMI-CENTENNIAL OF THE SAULT STE. Marie Canal, dating from the breaking of ground for construction, will occur on June 4, 1903. A movement is now on foot to appropriately celebrate this occasion, and a memorial has been sent to Congress to this end asking for $50,000. This memorial states that at that canal can be witnessed the greatest concentration of commercial tonnage traffic on the globe. During 1901 over 28,000,000 tons of paying freight, valued at nearly $300,000,000, passed through this 200-ft. wide channel. This is a greater volume of freight than passed between Europe and America in the same time; and the Suez Canal tonnage for 1901 was less than one-third of that of the Sault Canal. Fifty years ago a dozen horses, operating a flat-rail tramway and plank road, moved all the freight then passing to or from Lake Superior.

THE COST OF U. S. BATTLESHIPS PER TON, of hull, machinery and fittings, but exclusive of armor and armament, ranges from $385 in 1896 to $656 in 1890, according to a late report to the House Naval Committee made by Rear-Admiral F. T. Bowles, Chief Constructor, U. S. N. The report says that the $385 for the "Kearsarge" and "Kentucky" certainly included no profit to the contractors, and Admiral Bowles believes that the contract prices of $401 to $406 per ton for the last four battleships—the "Missouri," "Ohio," "Virginia" and "Pennsylvania"—contracted for in 1898-1901, do not include unreasonable profits. He admits that the building of the earlier battleships probably netted a considerable profit to the builders.

THE WORLD'S DEBT, says "Le Matin," of Paris, in commenting on a statement recently made by Mr. O. P. Austin, Chief of the U. S. Bureau of Statistics, amounted in 1801 to 3,000 millions of dollars; in 1848 it was 8,400 millions; in 1901 it was 31,800 millions. In this period only two great nations have reduced their national debt: England, in 40 years, reduced her debt by 1,000 millions, and the United States by over 1,400 millions. The Austrian debt increased from 600 millions in 1850, to 1,700 millions in 1901; Germany, from 116 millions in 1870, to 550 millions; Italy, from 1,400 millions in 1869, to 2,583 millions; Russia, from 400 millions in 1853, to 3,000 millions in 1900; and France has increased her debt from 1,000 millions in 1852, to 5,800 millions at the present time. "Le Matin" concludes that some of the nations named are closely approaching the limit of taxable endurance among their peoples.

A 50-TON METEORITE has been unearthed in Western Mexico, near Mocorito, by Prof. Henry A. Ward, of Chicago. It is 13 ft. 1 in. long, 6 ft. 4 ins. wide by 5 ft. 4 ins. thick, and was buried 20 ft. in the earth; but to transport it 71 miles to the seacoast would cost $50,000, and it is left, for the present at least, where found. The existence of the huge meteorite has been known for many years in the form of rumors, but Prof. Ward is the first to find and intelligently investigate it. This stone, however, is exceeded in weight by the "100-ton" meteorite brought from Greenland by Lt. R. C. Peary, the Arctic explorer.

UP-TO-DATE CHINESE ENGINEERING.

By L. F. Bellinger, M. Am. Soc. C. E.*

The photographs reproduced in the accompanying cuts were taken by Prof. G. D. Brill while on his rather extended travels in China during the past four years, in the employ, first, of the Chinese Government, and latterly, of the U. S. Agricultural Department.

A turbine wheel 6 ft. in diameter, and especially a combination of the Jonval turbine and an impact wheel, is not what might be expected by a

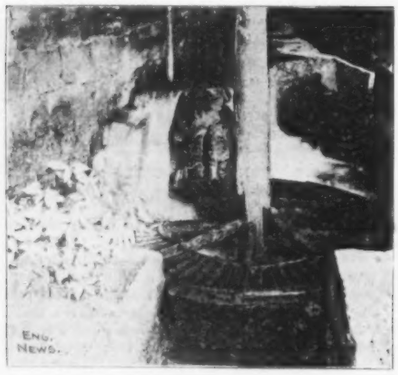

Fig. 1. A 6-ft. Wooden Turbine Water-Wheel, Western China.

European in West China, 1,350 miles up the Yang Tse, and yet this was exposed to the camera, 50 miles above Wan Hsien, and is reproduced in Fig. 1. The masonry of the wall on the left, and the masonry in the foreground on each side of the tail race, is not to be despised. The method of holding the rim to the arms by wooden "cotters," and the keying of the arms to the wooden shaft are well shown. The shaft itself and the "anti-splitting" collar at the top of the cut, are superior to shafts of wooden turbines, as at present manufactured on top of Lookout Mountain, in northeast Alabama, by "moonshiners."

Fig. 2 shows an overshot water wheel about 5 ft. in diameter, working a trip hammer in an incense mill at Ku Ling, below Han Kow. Through the horizontal shaft of the water wheel are passed two square wooden pins 90° apart, as shown. These pins strike on the left end of the large wooden tilting beam in the foreground, causing the right end to act as a hammer or flail in bruising the incense stalks shown at the right. The anvil is below and behind the rocks in the foreground. (A somewhat similar trip-hammer was until recently in daily use at the works of the Remington Arms Co., at Ilion, N. Y.) This incense has a ready market and extensive sale in the districts "patronized" by the little pot-bellied gods before whom it is burned. The main technical feature is the "sight feed lubricator" of split bamboo, which pours water on the shaft bearing (of rock) in the foreground. This little stream of water also keeps the shaft and bearings cool.

The undershot wheel is next in order and is shown in two different locations; one being on a side channel near a rapid in the river, the other at a rock-fill wing dam. Both are in Hu Peh province, near Yang Lo Teng, and are made entirely of bamboo; floats, buckets, rims, spokes, axle, irrigating trough, journals, pillars, wind bracing and all. Both are used for irrigation purposes. The one at the river is 30 ft. in diameter and has a 4-ft. face; the one at the side channel is larger than the average size, being 35 ft. in diameter, with a 4-ft. face. The type of boats and boatmen is seen at the left of the wheel above the wing dam.

The water is raised in the same manner in both wheels, viz., large bamboo stalks are sawed off at the joints, leaving the hollow stem about 4 ins. inside diameter and 4 ft. long. These are placed at an obtuse angle with the plane of the rim, squared on the sides to afford some resistance to the water, and thus aid the floats, which are at 90° to the plane of the rim. As the current forces the wheels slowly around, the buckets rise out of the water, and discharge into the trough at the top about two-thirds full. While a little trickles out on the ascent and shows in the cut as white threads of water, the economical height at which to place the trough is seen to be well chosen. All the water is discharged by the time the greatest altitude is reached, and the water flows from the trough into the irrigating ditches.

*159 Cumberland St., Brooklyn, N. Y.

With apologies to Mr. E. D. Leavitt, the following comparison of the cost of raising water, between the Chinese type of wheel, and that described in Engineering News of Nov. 21, 1901 (p. 396), is herewith given in the "deadly parallel columns":

Items.	Wheel—American.	Wheel—Chinese.
Diameter of wheel, ft.	65	55
Height water is lifted, ft.	50	25
Face of wheel, ft.	12	4
Number of buckets	550	48
Revolutions per minute	7	1
Peripheral speed (per second), ft.	12	2
Capacity, gallons per 24 hours	75,000,000	120,000
Cost of wheel (about)	$60,000	$1.80
Investment pr 1,000 galls. capacity, cts	80	1½
Investment per 1,000 galls. capacity, per 25-ft. lift, cts.	40	1½

We may offset the cost of the wing dam for the Chinese wheel, by the boiler and electric plant of the American wheel as being about in the same proportion of cost as given above. The capital invested in the Chinese wheel is arrived at as follows: Prof. Brill states that five men can build such a wheel in a week, and that the average wage in that section is 6 cts. per day. Then we have this table:

Cost of Constructing One Wheel.	
3 farmers at 5 cts. per day each	15 cts.
1 skilled wheelwright at 7 cts. a day	7 "
1 general superintendent at 8 cts. a day	8 "
The total, each day makes the owner feel like..	30 cts.

This for six consecutive days makes a grand total of $1.80 per wheel! It is even said that some wealthy landlords have as much as eleven or thirteen dollars invested in such improved machinery! As these wheels displace much manual labor, they are not liked by the labor organizations (?) who favor the good old method of the "strike-water," shown in Fig. 5 and described as follows:

To the bucket are attached on each side two ropes, one at the top, the other at the bottom. The other ends of the ropes are attached to the hands of the "strikers." At the left of the view and out of sight below the bank, is the lower ditch. The upper ditch leading to the rice field is at the right. The "directions for use," assuming the bucket to be on the bank, are, to pull the bottom cord and swing the bucket to the left, lower the whole into the water, with the mouth of the bucket at a downward angle so as to dip under. Next, pull on the rope at the top of the bucket, and it is raised full of water, and at the same time pulled to the right, across the bank toward the upper ditch. Now, by pulling in a little on the bottom rope, the bucket is turned into the horizontal position seen in the cut, and the contents discharged into the field ditch as seen. A little study of the cut will convince any one that in China as well as here, it takes much practice, "team work" and constant application to become a successful "striker." The "team work" is looked after by the sinister-looking gentleman on the bank, wearing the long-sleeved "duster." The house on the hill across the river is far better looking than many to be seen in this country.

The view is taken at I-Chang, on the Yang Tse. The efficiency of the "strike-water" as compared with the 30-ft. irrigation wheels, depends largely on the "moral," as well as the "heat," units applied to the "strikers" by the overseer, consequently no numerical data are given. The "strike-water" seems to be used on low lifts, and on plantations

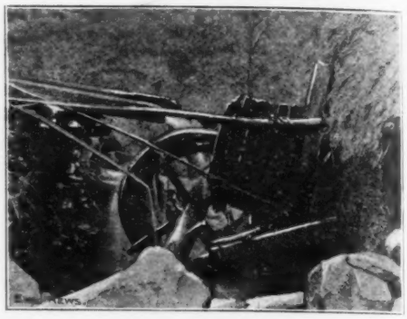

Fig. 2. Trip-Hammer Incense Mill at Ku Ling.

short of capital. With a high lift and $2 to the good, the wheels are used.

Turning now from hydraulic engineering to structural engineering, we note first, the arch in Fig. 6, with its nicely-cut voussoirs and spandrels. It seems to be a slightly pointed Gothic arch with its 15-ft. wide toll-house on top. Using the people nearest the arch as a unit of measurement 5 ft. long, the span is about 130 ft., and the rise 65 ft. The rock faced masonry retaining wall on the right seems to be in fair condition also. This bridge is at Wan Hsien, about 1,300 miles up the Yang Tse, and the type is fairly common in this part of China. It is far better than the little stone arches in Eastern China, which are only wide enough for one mule in its soberest condition to navigate.

The methods used in computing the proportions of this arch, and the retaining wall, would be interesting if obtainable. The results are more pleasing than those to be seen in a helicoidal oblique arch built at Penn Yan, N. Y., in which the ring stones were cut according to a book describing an arch skewed to the *right*, as is usual in text-books, while the arch as built, actually skews to the *left*!!

Fig. 7 shows the Summer Palace, near Pekin. This was destroyed by the British in the '50's, was rebuilt by the Empress Dowager about 15 years ago, and is now fitted with plate glass windows, electric lights, numerous Connecticut clocks, and a barrel organ, and the lake is equipped with steam launches. The temple on the hill near the center was burned by the Italians last spring.

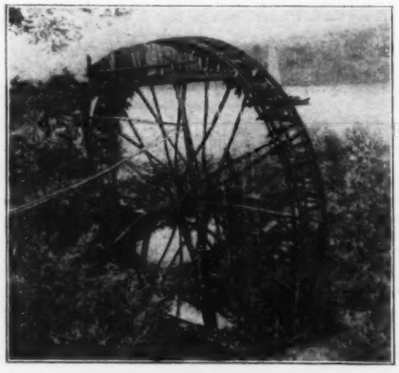

Fig. 3. 35-ft. Wheel on Side Channel.

Fig. 4. 30-ft. Wheel and Wing Dam.

UNDERSHOT BAMBOO WATER-WHEELS RAISING WATER FOR IRRIGATION.

Fig. 8 shows the same lake, the gateway to the boat landing at the left, the launches, and what is really artistic piece of work, viz., the white marble bridge across the lake. The graceful curve of the spandrel and roadway, and the symmetri-

Fig. 5. The "Strike-Water" System of Lifting Water for Irrigation.

cal arrangement of the arches would do credit to any engineer. It certainly enhances the beauty of the buildings and grounds of the Summer Palace to a great extent.

THE EFFECT OF MELTING STEEL WITH IRON IN THE CUPOLA.*

By H. E. Diller.

It is well known that melting steel with iron in a cupola adds strength to the resultant casting. But to what degree this is so, and the best proportion of steel to use are not so clearly understood. In order to learn something more definite in regard to these two subjects, and also to see if it were possible to trace some connection between the percentage of total carbon in the iron and the tensile strength, I have made the tests summarized in the accompanying table.

The tensile and transverse strength given in the table are the average of two, and in some cases three, test bars. For the tensile strength a 1⅛-in. round bar was used. The transverse strength was obtained from a 1-in. square bar placed on supports 12 ins. apart.

The object sought in the classification into sets was to have the silicon about equal in the tests of each set, the amount of the other elements being as nearly alike as it was possible for me to get them.

SET 1.—Tests Nos. 1 and 2 show comparatively little difference in the chemical contents, except in the manganese and graphite. As the manganese in No. 1 should be beneficial to the strength of the bar, the only way to account for the greater strength of the iron from No. 2 is the lower percentage of graphite, or the molecular structure resulting from the 25% of steel in the mixture.

*A paper presented at the convention of the American Foundrymen's Association at Boston, Mass., June 17 to 19, 1902.

SET 2.—Comparing Nos. 3 to 7 we find that the strength increases with the percentage of steel used and the decrease of total carbon, with the exception of No. 7. In this 37½% of steel was used, and the total carbon was less than in any other test, but it is weaker than either No. 5 or No. 6. This being a solitary case it can hardly be used as proof that 37½% of steel is more than it is well to melt in a cupola. But test No. 11, which also contained 37½% of steel and more carbon, was only a little stronger.

Test No. 4 was considerably weaker than No. 5, but its higher percentage of sulphur with its lower combined carbon would seem to indicate that these bars were either cooled slower, or poured from duller iron than were the bars from No. 5, which may account for their being weaker than the No. 5 bars.

SET 3.—In looking at Nos. 8 to 11 we see that No. 9, although containing 12½% of steel is no stronger than No. 8, in which there was no steel. And No. 10 with 1.06 combined carbon, and 12½% of steel, gives less strength than might be expected. As these tests are so much lower in manganese than Nos. 8 and 11, it may be that their weakness is due either to the lower manganese or to the conditions of melting, which reduced the percentage of manganese so much more than in Nos. 8 and 11. The four charges each contained about 50% manganese before melting.

SET 4.—Nos. 13 and 14, each from charges containing 25% of steel, show a marked increase in strength over No. 12.

We find that all the tests from charges containing 25% of steel are stronger than those from the charges containing but 12½%, with the exception of No. 5, which is stronger than two of the tests which had 25% of steel in the mixture.

The tests were made with pig iron, ferro-silicon and steel scrap, no cast-iron scrap being used. This was done in order to better control the percentage of the elements in the iron. In some cases when a large percentage of steel was added, it was necessary to use ferro-silicon to get the desired amount of silicon in the charge. To see how this and the steel mixed with the pig iron two tests were taken from No. 13, which contained 1,000 lbs. of steel, 400 lbs. of ferro-silicon (8.5% silicon) and 2,600 lbs. of pig iron. The charge was tapped from the cupola into a ladle, and the tests taken at different times, as the iron was being poured from the ladle. The one sample contained 2.63 and the other 2.54% of silicon. Two tests taken in the same way from No. 14, contained 1.97 and 1.94% of silicon. This charge was made up of 1,500 lbs. steel, 450 lbs. ferro-silicon, and 2,050 lbs. of pig iron. Similar tests from charge No. 2, which was made up of 1,000 lbs. steel and 3,000 lbs. pig iron, contained 1.50 and 1.52% of silicon. These three cases offer pretty strong proof that the pig iron, steel, and ferro-silicon mixed thoroughly.

Although of a limited number, the tests given seem to indicate that 25% of steel will add about 50% to the strength of the iron; and 12½% of steel, approximately 25%. The tests containing 37½% of steel were hardly as much improved in strength as those with 25% of steel, from which we may infer that the limit of the amount of steel it is beneficial to melt with iron in a cupola, is between 25 and 37½%.

EXPERIMENTS ON TRAIN RESISTANCE WITH ELECTRIC CARS.

In the May 3 issue of the "Street Railway Journal" a contributor, Mr. W. J. Davis, Jr., offers a new formula for train resistances, deduced from a recent series of experiments. The results given diverge considerably from the figures obtained from accepted formulas for tractive resistance on steam railways. The article is quite short, and gives no detailed data in regard to the experiments. The following is a condensed abstract of Mr. Davis' paper:

The experiments were made for the General Electric Co. on a section of the Buffalo & Lockport Ry. (electric), in the spring of 1900. The

Fig. 6. Wau Hsien Bridge on Yang Tse River, 300 Miles Above I Chang.

section of track used, between Pendleton and Lockport, is on tangent and has no grades exceeding 0.25%. It is laid with 90-lb. rail and has a well ballasted roadbed.

It was desired to secure data upon which could be based a formula for tractive effort which would be applicable to high speed and medium speed running on electric railways, particularly for traffic units consisting of only two or three cars, or even a single car. For this purpose an electric locomotive, one baggage and three passenger cars were provided to make up different test trains. The locomotive was one in use on the Buffalo & Lockport Ry., weighed 39 tons, and was specially geared to give maximum speeds of 55 to 60 miles per hour at normal line voltage. The cars were standard railway cars belonging to the Erie Ry., and weighed about 26 tons each.

The method of test consisted in bringing the train up to maximum speed as rapidly as possible,

FIG. 7. SUMMER PALACE OF THE EMPEROR OF CHINA, NEAR PEKIN.

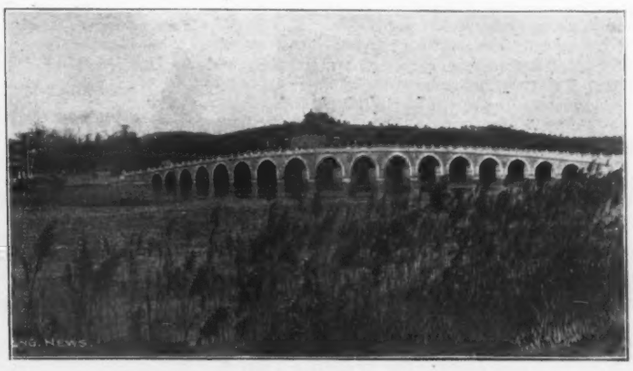

FIG. 8. WHITE MARBLE BRIDGE ACROSS THE LAKE AT THE SUMMER PALACE.

	Reference No.	Chemical composition. Silicon.	Sulphur.	Phosphorus.	Manganese.	Carbon: Combined.	Carbon: Graphitic.	Carbon: Total.	Breaking strength: Tensile.	Breaking strength: Transverse.	Steel used in mixture, %.
Set 1	1	1.43	0.047	0.564	0.82	0.67	3.14	3.81	23,000	2,550	0
	2	1.50	.065	.532	.33	.64	3.44	3.08	30,500	2,840	25
Set 2	3	1.76	.062	.488	.53	.51	3.12	3.63	22,180	2,440	0
	4	1.76	.139	.515	.57	.43	2.94	3.37	27,000	2,770	12½
	5	1.77	.069	.539	.49	.56	2.87	3.43	32,500	3,120	12½
	6	1.83	.100	.610	.55	.51	2.44	2.95	36,860	3,280	25
	7	1.75	.089	.598	.35	.74	2.12	2.86	30,160	3,150	37½
Set 3	8	1.96	.104	.446	.44	.63	3.18	3.81	21,950	2,230	0
	9	2.12	.037	.410	.26	.38	3.26	3.64	21,890	2,470	12½
	10	2.16	.060	.315	.20	1.06	2.30	3.36	26,310	2,670	12½
	11	1.97	.093	.470	.48	.57	2.83	3.40	32,530	3,050	37½
Set 4	12	2.35	.061	.515	.56	.54	3.40	3.94	21,990	2,200	0
	13	2.53	.104	.490	.54	.60	2.56	3.16	33,390	2,850	25
	14	2.36	.064	.327	.24	1.08	2.15	3.23	31,560	3,200	25

then throwing off the power and coasting. A Boyer speed recorder, with chronograph attachment, mounted in the locomotive, gave records of speed and time during coasting. Tests were carried out on this plan, using first the full train of locomotive, baggage car and three coaches and then in successive tests leaving off one car until the locomotive alone remained.

The records were interpreted as follows: It was thought proper to base any formula to be derived upon theoretical considerations; in other words, to properly recognize in the expression all the factors that contribute to train resistance. These

factors were taken to be (1) axle friction, considered constant for all speeds; (2) rail or rolling friction, assumed directly proportional to the speed; (3) air resistance, considered to vary as the square of the speed and directly as the cross-sectional area of the car, and to depend also upon the end shape of the car and the number of cars in the train. It was recognized that the train resistance also included the friction of the motors and gearing, and that the speed-time curve would be affected by the inertia of the revolving parts. The latter factor was calculated and properly allowed for; the former factor was allowed for on the basis of the results of special tests made at the factory. The formula therefore neglects both these items. According to the preceding, the form of the expression whose coefficients are to be evaluated is

$$f = b + c\,V + \frac{d\,A\,V^2}{T}\,[1 + m\,(n-1)].$$

in which

- f = tractive resistance, in lbs. per ton.
- V = velocity of train in miles per hr.
- T = weight of train in tons.
- A = cross-section of one car in sq. ft., all cars assumed of same cross-section.
- b = tractive resistance due to journal friction, in lbs. per ton.
- c = coefficient due to rolling resistance, in lbs. per ton.
- d = air resistance in lbs. per sq. ft. of cross-section.
- m = coefficient representing effect of one additional trailing car upon air resistance.
- n = number of cars in train.

The tests were made at a time when there was little wind, so that no correction was needed for this. The coefficient d was determined from a series of special tests made by mounting on the front of the locomotive a wooden shield hinged at the bottom, and measuring the pressure at the top by a suitable system of levers. These tests gave the formula

$$d = .004\ V^2.$$

In the coasting tests with the different trains it was found that each additional trailer increased the air resistance of the train by 10%; in other words, the coefficient m is equal to 0.10. The other coefficients were found to have the values b = 4.0, c = 0.13. The resulting formula therefore is

$$f = 4 + 0.13\,V + \frac{.004\ A\ V^2}{T}\left[1 + \frac{n-1}{10}\right].$$

For application to ordinary interurban cars running at high speeds it was thought safer to modify this formula somewhat, pending further tests. On account of the rounded vestibule ends of such cars, the coefficient d was reduced to .0035, while for various reasons not stated the coefficient b was increased, giving the formulas below:

For 25-ton car, area of cross-section 85 sq. ft.,

$$f = 8 + 0.13\,V + 0.297\,\frac{V^2}{T}\left[1 + \frac{n-1}{10}\right].$$

For 35-ton car, area of cross-section 100 sq. ft.,

$$f = 6 + 0.13\,V + 0.350\,\frac{V^2}{T}\left[1 + \frac{n-1}{10}\right].$$

For 45-ton car, area of cross-section 110 sq. ft.,

$$f = 5 + 0.13\,V + 0.385\,\frac{V^2}{T}\left[1 + \frac{n-1}{10}\right].$$

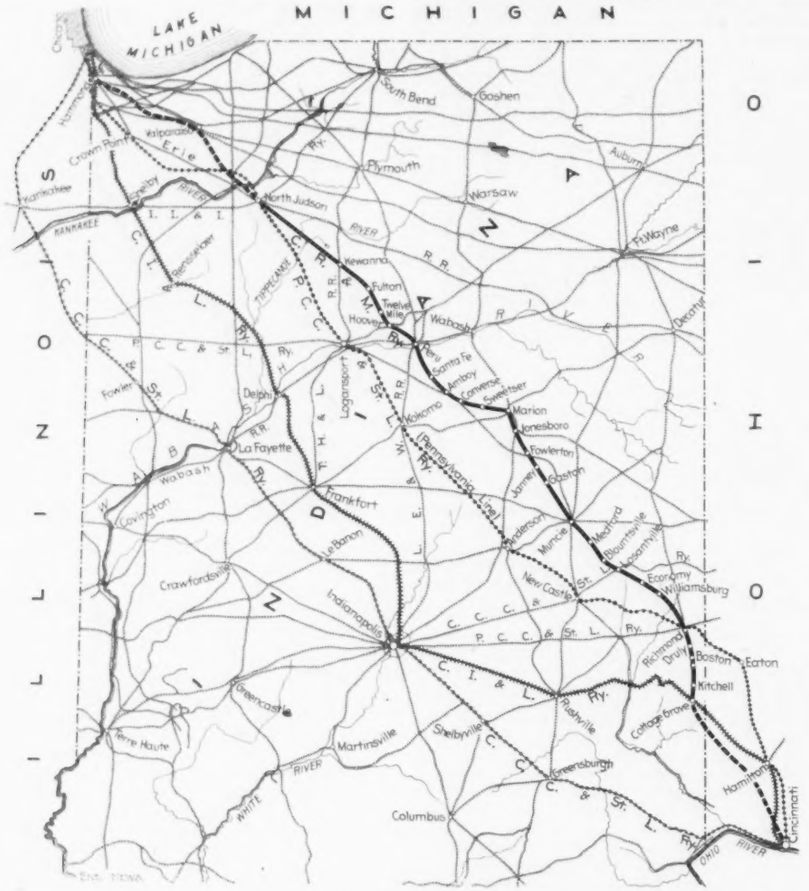

FIG. 1. MAP OF THE CINCINNATI, RICHMOND & MUNCIE R. R., WITH EXTENSIONS, SHOWING ALSO THE COMPETING ROUTES BETWEEN CHICAGO AND CINCINNATI.

A NEW RAILWAY BETWEEN CHICAGO AND CINCINNATI.

In March, 1900, the Cincinnati, Richmond & Muncie R. R. Co. was incorporated to build a line of railway northwest from Cottage Grove, on the Cincinnati, Hamilton & Dayton Ry., to Muncie, with extensions to Chicago, Ill. It was originally intended to run from the Cincinnati, Hamilton & Dayton Ry. at Cottage Grove to the Erie Ry. at North Judson, a distance of 168 miles, with running powers over these two lines into Cincinnati and Chicago respectively. The company now intends, however, to have its own line throughout, and an independent company (the Chicago & Cincinnati R. R.) has been organized to build from North Judson to Hammond, about 50 miles. Here connection will be made with some line which will give direct access to Chicago. Another company (the Cincinnati & Indiana Western R. R.) has been incorporated to build southeast from Cottage Grove to Cincinnati, about 40 miles.

Construction was not commenced on the C. R. & M. R. R. until May, 1901, but by December 1st it had been opened for traffic to Peru, 115 miles. The line was also practically completed and track laid to North Judson in January, with the exception of a stretch of eight or ten miles between Peru and Hoover, where some heavy work was encountered. The line is now open for traffic from Cottage Grove to North Judson, 168.4 miles, and the entire line, from Chicago to Cincinnati, is expected to be in operation before the end of 1902.

This road will be about 30 miles shorter than the other three existing routes; 308 miles by the Chicago, Indianapolis & Louisville Ry. and Cincinnati, Hamilton & Dayton Ry., 306 miles by the Cleveland, Cincinnati, Chicago & St. Louis Ry., and 298 miles by the Pennsylvania Lines. Fig. 1 is a map of the Cincinnati, Richmond & Muncie R. R., showing the approximate route of its extensions, and showing also the competing routes between Chicago and Cincinnati.

The line passes through a farming country, with occasional patches of timber, and traverses the manufacturing region of the Indiana natural gas belt. The principal towns on the line are Richmond, Muncie, Marion and Peru, all manufacturing centers, with glass works, iron works, agricultural machinery plants, general machinery works, a piano factory, and other miscellaneous industries. The country is rolling, and is nearly all cleared and settled. The material is mainly gravel and drift of varying quality, and is used both for filling and ballasting. For a large part of the distance the grading is quite light, the line conforming approximately to the surface, but there are some heavy cuts and high banks. The material is excavated by steam shovels and handled by flat cars with plows, and by the Rodger ballast distributing cars. The work has been carried out mainly by small contracts with local firms.

There are 17 steel plate girder bridges, aggregating 2,480 ft. in length; the longest spans are 100 ft., and the shortest 30 ft. Two of these bridges are over streets in Richmond, and have the Carnegie solid floor with triangular troughs. Another bridge crossing a street has a floor of transverse I-beams, closely spaced, the rails being laid directly on the beams with inside and outside angle iron guard rails. At Richmond, the White

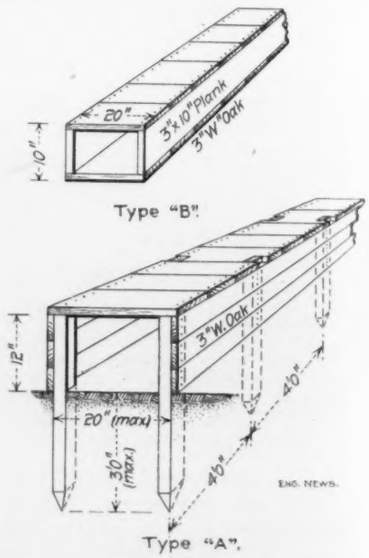

Fig. 4. Box Culverts.

Water River is crossed by a bridge 720 ft. long, having two spans of 100 ft. and 70 ft.; ten spans of 23, 30 and 45 ft., and seven trestle tower spans of 30 ft. The 70-ft. and 100-ft. spans have girders of reduced depth at the ends, the 100-ft. girders being 5 ft. 8¼ ins. deep at the bridge seats and

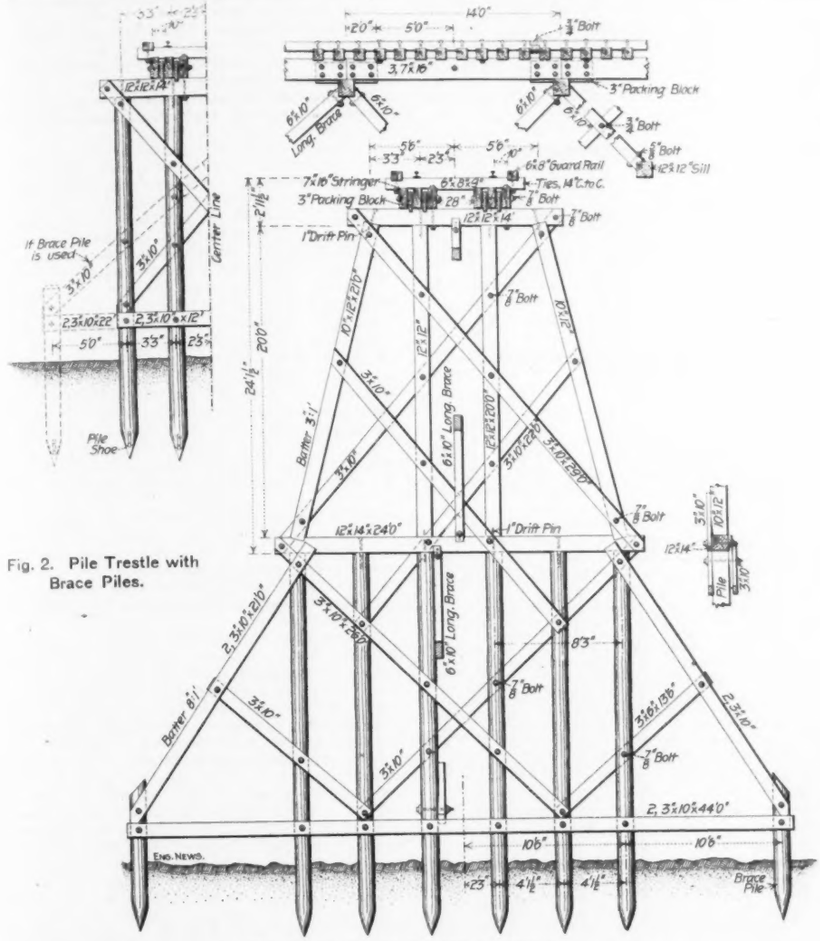

Fig. 2. Pile Trestle with Brace Piles.

FIG. 3. PILE AND FRAME TRESTLE.

10 ft. deep in the body. At Muncie the White River is crossed by a bridge of three spans of 80 ft. on concrete piers and abutments. Owing to the small headroom, this is a half-through bridge. The Wabash River is crossed at Peru by a bridge of five spans of 80 ft.; the Eel River near Hoover by three spans of 85 ft., and the Tippecanoe River near North Judson by three spans of 75 ft. Beyond this town the Iroquois River will be the only large river to be crossed. All smaller streams are crossed by pile trestles, having four-pile bents with X-bracing bolted to the caps and to horizontal bottom planks. On high trestles, the planks for the X-bracing extend beyond the main piles and are bolted to short brace piles beyond the line of the trestle. This somewhat novel construction is shown in Fig. 2, while Fig. 3 shows a high combination pile and frame trestle. This latter has no horizontal longitudinal bracing, or girths, but has longitudinal diagonal bracing between the framed bents, as shown. The trestles as well as the open pile culverts have timber bulkheads, thus eliminating end slopes of the banks and making the structures as short as possible. Timber box culverts are used in the banks, and the larger of these culverts are anchored by stakes driven in the ground, as shown in Fig. 4. There are two railways crossed by plate-girder spans, while five railways are carried over the line by similar spans, all having concrete abutments. The bridges are designed for the Class E-40 loading of Cooper's specifications, and are painted with a black graphite paint. All the steel bridge work was built and erected by the Wabash Bridge & Iron Works, of Wabash, Ind.

In the main the alinement is easy, with long tangents, but at certain points the line is quite crooked. The maximum grades are 1%, compensated for curvature; the sharpest curves are 5°, at present, but it is intended eventually to reduce most of these to about 2°. Many of the small streams are now crossed by low-level trestles, necessitating sags in the grade line. As is usual in this country, the railway was built with a view to getting a line opened at the earliest possible time, so as to develop traffic and earn revenue, while permanent improvements can be carried on subsequently, as required. To adapt the line for the high-speed through service which it will have to carry in competition with other lines, banks will be widened, cuts widened and trimmed to prevent caving, grades and curves regulated, and other similar work done.

The track is laid with 70-lb. rails (Am. Soc. C. E. section) for the main line and 56-lb. rails for the sidings. The rails are 30 ft. long, laid with broken joints, and spliced with 26-in. angle bars with four bolts. The ties are of white oak, obtained from West Virginia, and costing about 55 cts. each, delivered on the track. At most of the stations, excepting those at four or five of the larger towns, the freight track passes to the rear of the station building, the distance between main track and house track being 52 ft. c. to c. These sidings are from 1,300 to 2,400 ft. long. Passing tracks have their centers 14 ft. from main track centers. Split switches with 8-ft. switch rails and automatic switchstands are used in the main track, with No. 9 rigid frogs. No. 6 frogs are used in yards and side tracks. The frog and switch work was supplied by Pettibone, Mulliken & Co., of Chicago. It will be seen from the map, Fig. 1, that the line crosses a number of other railways, 17 in all; of these, two pass under and five pass over the C., R. & M. R. R., while the others cross at grade, most of these grade crossings being equipped with interlocking plants of the Union Switch & Signal Co.'s make. The standard fence has seven lines of barbed wire (closely spaced at the bottom) on posts 16 ft. apart. Plank wing and apron fences are placed at road crossings, with surface cattle guards having wooden slats parallel with the rails.

At Cottage Grove the line now ends in a spur track parallel with the C., H. & D. Ry., and at the rear of the station. At this point is a Y for turning trains, and there is a similar Y at South Richmond, there being no turntable at the shops. The existing shops, at South Richmond, are very small and the repair facilities limited, but the railway proposes to build new shops later. The water stations have wooden tanks of 50,000 gallons capacity, mounted on timber towers. At most of these the water is obtained from well points, 18 to 25 ft. deep, and pumped by steam or gasoline pumps. At Richmond, Muncie and Peru, the tanks are supplied with city water.

The largest station on the road is at Richmond, built of grey mottled Roman (small) brick and grey stone, with a red tile roof, the roof forming a porte cochere at the baggage-room entrance in the end of the building, as shown in the view, Fig. 5. A plan of the station is given in Fig. 6. The interior is finished with a cream-colored brick wainscot, and dull green burlap covering the walls above, the ceiling being in light colors and the floor of tile. All wood trim, doors, etc., are of dark oak. The principal room is the waiting room, with street and platform doors diagonally opposite. At one end are the women's waiting and toilet rooms, and at the other end are the smoking room and men's toilet room, with lavatory, marble fittings and open plumbing. Beyond these are the baggage and express rooms. The building is heated by hot air, and has combination gas and electric light fixtures. The station platform is of cement concrete. This building was designed by W. S. Kaufman, Architect, of Richmond, Ind., and built by Louck & Hill, contractors, also of Richmond. Stations of very similar design are built at Muncie, Marion and Peru, and a smaller brick station at South Richmond. At these places are also separate freight buildings, of timber construction, with corrugated iron sheathing and shingle roofs. The smaller towns have combination passenger and freight stations, of timber construction. These buildings are of two styles, both much alike, but one being larger than the other. The platform extends all round the building. The general design of the larger frame stations is shown in Figs. 7 and 8. The stations, sections houses, interlocking towers, water tanks, etc., are painted a deep orange yellow, relieved with white. All stations are equipped with the Harrington train-order semaphore signal.

The locomotive equipment comprises 12 locomotives (some new and others second-hand), including eight-wheel and ten-wheel road engines, four-wheel switch engines, and a tank engine. Ten more engines were to be delivered in April. The rolling stock comprises 14 cars for passenger service, and 354 for freight service, the latter including large eight-wheel cabooses. All the cars are new, and were built at the Laconia Car Works, Laconia, N. H. The passenger cars have vestibuled ends and are fitted with lamps for the Pintsch gas-lighting system. As the traffic is light the combination cars are made to serve four purposes, and are divided into four compartments of approximately equal size for smoking, baggage, express and mail.

Fig. 5. Passenger Station at Richmond, Ind.; Cincinnati, Richmond & Muncie R. R.
H. L. Jackson, Chief Engineer; W. S. Kaufman, Architect; Louck & Hill, Builders.

The headquarters of the company are at Rich-

mond, Ind. Mr. W. A. Bradford, Jr., is President; Mr. W. I. Allen, General Manager; Mr. H. L. Jackson, Chief Engineer, and Mr. T. E. Merritt, Master Mechanic.

THE PARALLEL OPERATION OF ALTERNATING CURRENT GENERATORS.

We reprint below the substance of two papers read before the Engine Builders' Association of the United States at their convention held on May 22 and 23 at Pittsburg, Pa. The two papers deal with the same general subject—the parallel operation of alternators and the design of engines and generators in such a manner that parallel operation is feasible without "hunting" or "pumping."

The first paper recites certain requirements for engine construction that are used as a standard specification by a leading electrical concern, and makes clear the meaning and the scope of these requirements, all from the electrical engineer's point of view. The second paper sharply attacks this specification and the spirit in which it is formulated, and considers on a broader and more general basis the nature of the ground which the specification is intended to cover.

The question of parallel running of alternators is generally considered as by itself; it may, however, be thought of as part of the much larger question of the flexibility, or adaptability, of the alternating-current system of power utilization. This adaptability is an important question, because it is the large and vital feature on which the alternating-current system attempts to rest its claims for superiority. Of the numerous weak points in this claim, the matter of parallel running is one of the least serious; it is generally believed that in the near future all troubles in connection with paralleling generators and other synchronous machines will have been overcome. Nevertheless, Mr. Longwell's lucid paper brings before one's mind the many complications involved in this one subject; and from this one can form an opinion as to what must yet be accomplished to realize that flexibility in alternating current working which certain electrical engineers already see existing.

THE ENGINE REQUIREMENTS FOR THE PARALLEL OPERATION OF ALTERNATORS.—By E. M. Tingley.*

In the following are given the principal clauses of a specification in use by the Westinghouse Electric & Mfg. Co., covering the matter of characteristics of engines driving direct-coupled alternators intended for parallel operation. The requirements are explained and some comment on them is added.

1. The engine governors should be so constructed that there is no tendency to cause a periodic transfer or surging of the load between one engine and another. This tendency may originate in the angular variation of velocity in different parts of the revolution which is common to all reciprocating engines, or to a sudden variation of load which will affect each governor in a slightly different manner, or to other causes that lead to a non-uniform speed. The engine governors should not be sensitive to such disturbances nor maintain or increase them.

The effect on the engines of a periodic transfer of load occasioned by hunting between two engines running in parallel is somewhat similar in effect to throwing the load on and off of a single engine at short intervals which may be measured by one or several pulsations in the combined turning efforts applied to the engine shaft. In some extreme conditions the pulsations of load may amount to more than the normal capacity of either engine. With no extreme load one engine may then alternately drive the other, which will evidently be a more severe condition than if the load were only applied and removed from a single engine.

If, under any case of pulsating load the engines do not tend to accentuate the pulsations in turning effort and speed, then a condition favorable to parallel running is attained.

2. Variation of the rotating part of the generator through one revolution, at any constant load not exceeding 25% overload, should not exceed 1-60 of the pitch angle between two consecutive poles from the position it would have if the motion were absolutely uniform at the same mean velocity. The maximum allowable variation, which is the amount the rotating part forges ahead plus the amount which it lags behind the position of uniform rotation, is therefore 1-30 of the pitch angle between two poles. Generally this is obtained by the use of a heavy flywheel.

In a two-pole machine this variation is equivalent to 3° as measured on the circumference of the rotating part; in a four-pole machine it is 1½°, and in a six-pole machine 1°, or as the number of poles increases the permissible angular variation decreases.

3. The engines should have practically the same characteristics of speed regulation, that the power delivered to their respective generators may be proportional to the load; that is, the same load on any engine should produce the same percentage drop in its speed. This is most readily obtained in engines in which at full load the speed drops from 3 to 5% below the no-load speed, as a slight change in adjustment of the governors will have less relative effect than in engines in which the speed drops only 1% under the same variation of load.

4. The use of governors which are adjustable while the engine is running is recommended. Slight adjustments of speed may then be made which will facilitate synchronizing the alternators or changing the load carried by the engines.

It may be noted that there is no attempt to tell how these results are to be obtained. This is a problem for the engine builders.

The alternators simply transform mechanical energy and electrical energy and their effect in connecting engines together is precisely the same as any other elastic coupling, and, as far as the engines are concerned, should be considered as such. The force tending to keep the generators in step is sometimes termed their synchronizing power. It is sometimes contended that this force should be made stronger or weaker to accommodate assumed engine conditions, but this can not be done without extensive changes in the generators. To make the force weaker reduces the inherent voltage regulation of the generators, and to make it stronger adds considerably to their cost.

Some of the effects of pumping may be reviewed by considering the simplest case in which pumping occurs, viz., when two alternators are in parallel with no external load. If the alternators will work in parallel under no-load condition, they will usually work together under load, or with one or more additional units. This is also the most severe condition of starting. When the two generators are first connected together at precisely the proper instant, no current unusual will happen for a few seconds, but soon the ammeters will show cross-currents between the alternators as pumping commences, indicating that the generators are no longer in the same phase, or there is an angular difference between the machines which did not exist at the moment of synchronizing. A sensitive wattmeter will also indicate that energy flows from one generator to the other, or one unit acts alternately as motor and generator to the other.

The voltage on the two machines is lowered by these cross currents, and is pulsating and therefore is unsuitable for lighting service. Synchronous motors and rotary converters connected to these generators may pump, or fall out of step, or otherwise cause trouble. The generators may also grow warm on account of these cross currents, or give out sounds, indicating unusual internal mechanical forces. If the pumping increases in severity, fuses may blow, circuit-breakers open, or the generators finally pull entirely out of step.

The engine meanwhile may perhaps not show that anything unusual is happening while the pumping continues, leading some to assume that the trouble is all in the generators, while it is only the result that is apparent and not the cause. If, however, as in some cases, it is possible by looking through the arms of the flywheels to see the change in relative angular position of the two machines, it will be seen that there is an actual vibration between the two machines, such as might be expected to occur with an elastic coupling between the engines.

The oscillations may be started either by the angular variation in speed which occurs in all reciprocating engines, or by changes of load. Usually additional flywheel effect in the rotating parts decreases the tendency to pumping. It is only when additional flywheel capacity increases the resonant effect that the additional flywheel is objectionable.

To assist the engines in parallel running, it is now usual to apply dampers to the poles of the generators and rotary converters and synchronous motors. Dampers do not ensure parallel running, nor are they absolutely necessary, as is shown from experience. The best and most effective form of damper may not reduce pumping to a reasonable amount in some cases, and in other cases parallel operation is accomplished practically without dampers.

The second paragraph of the specification limits the angular variation from uniform velocity solely to limit the cross currents between generators and rotary converters to what is considered a reasonable amount. If the angular variation is no larger than specified, the performance will be satisfactory.

The objection may be raised that the allowable angular variation is exceedingly small, especially on machines with a large number of poles. However, other authorities have given a value 1-6 smaller than that which we have adopted.

Engines running with cranks in step will give better performance as regards themselves than with cranks out of step, especially if the angular variation is large, since the angular difference between two generators may be at all times smaller than the difference from absolutely uniform rotation. With a large angular variation, however, the operation of rotary converters will be unsatis-

*Pittsburg, Pa.

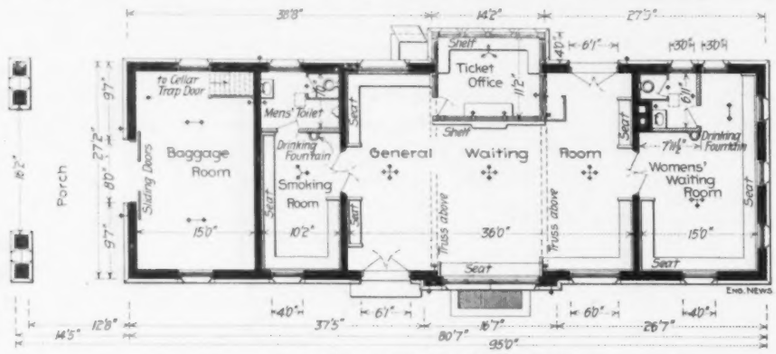

Fig. 6. PLAN OF STATION AT RICHMOND, IND.

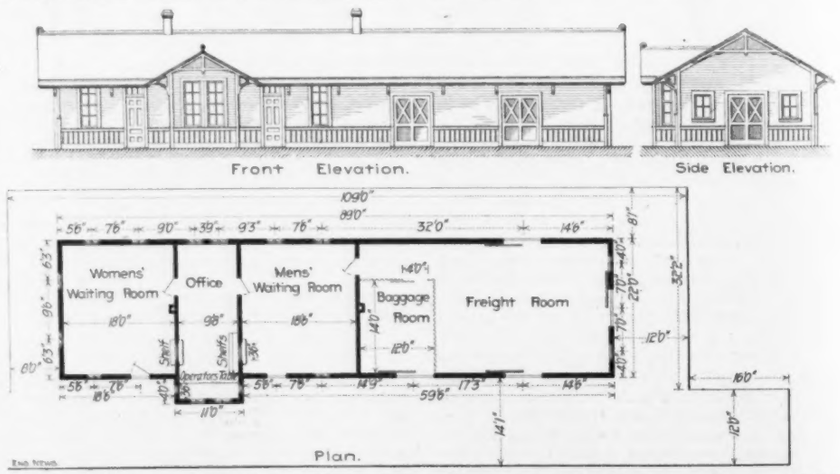

FIG. 7. PLAN AND ELEVATION OF COMBINATION FRAME PASSENGER AND FREIGHT STATION: CINCINNATI, RICHMOND & MUNCIE R. R.

factory. With the engine cranks out of step there may be larger cross currents between the generators, but the fluctuation frequently in the outside circuit will be smaller than before, since it will be the resultant action of two or more engines. In some cases the angular variation may be such that while parallel operation is possible, rotary converters or synchronous motors are inoperative or unsatisfactory.

Adjustable governors are recommended in the specification for the purpose of transferring the load from one generator to the other in order that the load may be readily cared for at the switchboard, or reduced so that the generator switches may be opened without injurious arcing. Usually the engine governors will vary in their own adjustment and it becomes necessary to correct this from time to time in order to divide the load properly, since all the governors may not regulate the same throughout the total range of load. Adjustable governors also enable an unloaded engine to be synchronized with a loaded engine.

THE REQUIREMENTS FOR THE PARALLELING OF ALTERNATORS AS VIEWED BY THE ENGINE BUILDERS.—By Henry E. Longwell,* M. Am. Soc. M. E.

The parallel operation of alternating-current generators direct-connected to reciprocating engines has, during the past five years, been the subject of many learned discourses, by many learned electricians. Awed by the formidable array of mathematics, Greek letters and scientific terms, we engine builders have sat humbly at the feet of the masters hoping vainly that there might be let fall some crumb of knowledge that we could assimilate and thereby progress

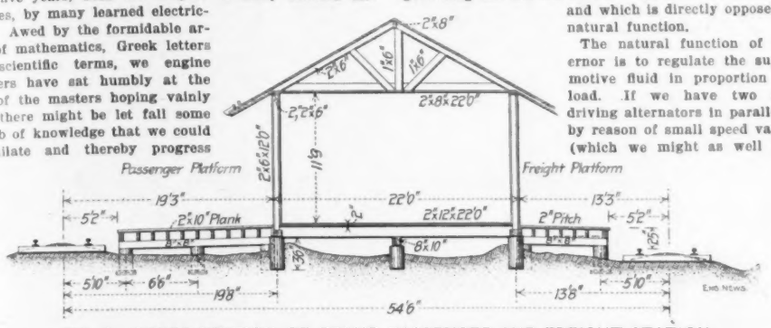

FIG. 8. CROSS-SECTION OF FRAME PASSENGER AND FREIGHT STATION.

—be it ever so little—towards a reasonable comprehension of the matter. What the problem needs for its complete and final solution is the advent of another Admirable Crichton, in whom the highest knowledge of electrical and mechanical science will be combined. Failing this, the solution must be the joint work of two or more individuals, with different training and different ways of thinking, and consequently the problem of paralleling alternators is now, and doubtless will be for years to come, complicated with the additional and perhaps equally difficult problem of paralleling brains.

It is not the intent of this paper to advance any unfailing receipt for making alternators run in parallel, but rather to call attention to the fact that there are certain things which the electricians have not told us that would be helpful to us if we knew them, and that some of the things they have told us are wrong; and, further, to suggest that there is a broader line of investigation than has been generally followed, which will include the action of the generator on the engine, as well as the action of the engine on the generator.

The electrician starts out with the assertion that no electrical question is involved. The stereotyped formula is that "if the alternators are run at uniform speed, and at the same frequency, the paralleling will take care of itself." This we concede without argument, for the reason that it does not have anything to do with the practical case and consequently it makes no particular difference whether it is true or not. If the prime mover is to be a reciprocating engine, the speed will not be absolutely uniform. It will vary during a single revolution, owing to the irregularity of the tangential effort on the crank pin, and it will vary from revolution to revolution because automatic governing is only a series of approximations above and below the mean speed. This is the actual condition we have to meet and it is time wasted to discuss ideal and impossible conditions. Admitting that these irregularities, which must exist to a greater or less degree, create certain electrical disturbances in the generators, it must be conceded that these electrical disturbances are communicated from one generator to another, and that there is a resultant reaction back on the engine. It is not enough for the engine designer to merely consider the action of his engine as an independent unit; it is equally necessary that he should have knowledge of the character of the reaction from the generator.

There are to-day quite a considerable number of installations which by dint of strenuous effort blindly applied and more or less good luck have been made to operate in parallel quite satisfactorily, but as to the reasons for success or failure opinions have differed so widely that it may be safely said that there is no theory that is not open to attack from some point or other. Some authorities will tell you that dash pots on the governors did the business, others that the turning moment of the engines was improved; still others will say that the use of copper pole tips or dampers on the generators is what turns failure into success. I have in mind a certain large installation in which the early attempts to parallel the alternators were far from successful. Shortly afterward the plant was operating in parallel regularly and satisfactorily. I made special inquiry as to what had been done to bring about the result, and my informant said: "Nothing, so far as the apparatus is concerned; we have just learned how to do it—that is all."

In a great many instances the difficulties experienced in paralleling alternators have been more or less completely overcome by tinkering with the governing mechanism on the engine, and consequently it has become fashionable to say that the troubles originate in hunting, oscillating, or otherwise faulty governors. This, however, is an unfair statement. Coincidence and cause are two entirely different things. The interaction between the generators is not necessarily caused by the hunting or oscillating of the governors, even though both phenomena are coexistent, and even though the latter tends to aggravate the former. A more fair statement of the case is, that the parallel operation of alternators imposes a duty on the governing mechanism of the engine, which is abnormal and which is directly opposed to its natural function.

The natural function of a governor is to regulate the supply of motive fluid in proportion to the load. If we have two engines driving alternators in parallel, and, by reason of small speed variations (which we might as well frankly admit are unavoidable), one generator advances ever so little ahead of the other, it takes more load. To restore equilibrium we ought to be able to reduce the steam supply to the engine that is leading and to increase the supply to the engine that is lagging behind. Now the natural tendency of the governor is just the opposite; i. e., to increase the steam supply to the heavily loaded engine and make it capable of taking more load, and to decrease the steam supply to the underloaded engine and make it less capable of taking its share of load. Furthermore the nearer perfect the governor is as regards the performance of its natural duty, the more promptly and vigorously it does the right things at the wrong time. Obviously a governor, unless endowed with intelligence, cannot assist parallel operation, and the best we can hope to do is to hobble it in such a way as to make it offer as little opposition as possible. In other words, we must sacrifice as far as is safe, all the qualities that have hitherto been regarded as synonymous with excellence, and make the governor so that it will not act quickly under any circumstances, and will not respond at all to moderate changes in load or speed. Hence, dash pots, friction brakes, etc., not because the governor is faulty, but because we must needs make it so to prevent its resisting the contradictory demands of the electrical part of the plant. No properly designed governor on an engine in any service other than that of running alternators in parallel requires any of these retarding devices, and their presence ordinarily would be an open confession of faulty design.

As regards the required degree of uniformity of angular speed, a common specification issued by one of the leading manufacturers of electrical machinery reads as follows:

Variation of the rotating part of the generator through the revolution at any constant load not exceeding 25% overload should not exceed 1-60 of the pitch angle between two consecutive poles from the position it would have if the motion were absolutely uniform at the same mean velocity. The maximum allowable variation, the amount the rotating part forges ahead plus the amount which it lags behind the position of uniform rotation, is therefore 1-30 of the pitch angle between two poles. Generally this is obtained by the use of a heavy flywheel.

Another manufacturer makes these limits 1-72 and 1-36 respectively.

This requirement presents no particular difficulty, except in the case of slow-moving engines coupled to generators of high frequency, in which case the flywheel weights assume proportions that are fearful to contemplate.

In certain instances we have made the angular variation within the specified limit, and even with the governor made as faulty as is safe, the paralleling has been unsatisfactory.

Since keeping within the specified departure from uniform rotation does not always insure success, we are led to make inquiries as to just what is the object of this specification and to wonder whether it may not be faulty or incomplete, or subject to modification.

In a paper read before the American Institute of Electrical Engineers on Oct. 25, 1901, it is stated in substance that the object of the specification is to limit the amount of cross current that can flow between the generators. With an allowed displacement of 1-72 of the pitch angle between two poles, ahead or behind the position corresponding to uniform mean speed, two generators might have a maximum relative displacement of 1-36 of the pitch angle between two consecutive poles. With this displacement it is stated that the cross current will be 10.9% of full-load current, *provided* the electrical characteristics of the alternators are such that the short-circuit current is 2½ times full-load current. Now we find that for various reasons—constructional or otherwise—alternators are actually built giving short-circuit currents as low as 2½ times full-load current, while others are known to give as much as six times full-load current on short circuit, and all of these are supposed to come within the limits of standard representative practice. If between the generators giving 2½ times full-load current on short circuit when displaced 1-36 of the pitch angle between two poles, the cross current is 11% of the full-load current, then the cross current between the generators giving six times full-load current on short circuit when the phase displacement is 1-30 of the pitch angle between two poles—which displacement is allowable under the more liberal specification—would be a little over 31% of the full-load current, nearly three times as much as the other.

If the amount of cross current allowable is a very important matter, it does not seem reasonable that the manufacturer of alternators should put out an invariable specification to cover the requirements of generators which differ so widely. If 31% cross current is allowable, why should the engine builder be burdened with the expense of making a flywheel to give a displacement which will cause only 11% cross current? If, on the other hand, 11% cross current is near the allowable limit, why should the engine builder be blamed when the generator builder furnishes machines that will give 31% cross current with the specified displacement?

We are next led to inquire what is the effect of the cross current and we learn that it represents "synchronizing force" or the tendency of the generators to pull each other into step if the phases are displaced. We also learn that the force is such a percentage of the full-load torque of one machine, as the cross current is of the full-load current.

For example, in a generator having a full-load capacity of 750 K-W.—which is approximately 1,000 electrical HP.—running at 100 r. p. m., the full-load torque, or the resistance offered by the load would be approximately 10,000 lbs. applied at a radius of 5 ft. 3 ins. With two such units in parallel, if the phase displacement is such that the cross current is 20% of the full-load current of one machine, then the force tending to pull the machines into synchronism is equivalent to that of a spring tensioned to 2,000 lbs., and connecting the two generators at radial points 5 ft. 3 ins. from their respective centers. If the total load of the two generators is 2,000 HP., we may consider that with this amount of cross current flowing one generator is carrying 1,100 HP. and the other only 900 HP.; or that the resistance at 5 ft. 3 ins. radius is reduced to 9,000 lbs. in one generator and increased to 11,000 lbs. in the other.

We have been told that this synchronizing force is what makes paralleling possible and that the more we have of it the better; we are told that it checks the displacement of the rotating parts of the engine resulting from the irregular crank-pin effort, and that with great synchronizing power in the generators, it requires a decided effort on the part of the engines to prevent the generators running well in parallel. This looks so plausible that we have for years accepted it against the evidence of our senses, when in fact there is just one small grain of truth in it, i. e., that some synchronizing force is necessary to make paralleling at all possible.

Synchronizing force cannot pull two generators into phase and hold them there any more than the force of gravity can pull an ordinary pendulum to the vertical position and hold it there. If we displace an ordinary pendulum to one side of the vertical position and release it, the force of gravity tends to pull it to a vertical position and to resist its going beyond that position, yet were the force ever so many times as great as it really is, it could never bring the pendulum to rest without the intervention of some extraneous force like friction or the resistance of the air. If we have two masses in space connected by a spring capable of extension and compression, and if we displace these masses with respect to each other so that the spring is under stress, these masses if released would approach and recede from each other forever if subjected to no other forces, the amplitude of the motion depending on the primary displacement, and the period on the relation between the spring force and the masses. The action of the synchronizing force between the alternators is analogous to the action of gravity on the pendulum or to the action of the spring connecting two otherwise free masses as in the illustration cited above. The synchronizing force tending to check the relative displacement be-

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tween the generators exists only after the displacement has occurred; when the generators are in phase the force is zero, and consequently there is nothing to hold them there.

I believe I am saying something new when I make the assertion that in every practical case, the effect of the synchronizing force of the alternators is to increase the irregularity of the angular speed of the engine instead of to diminish it. On first consideration this proposition seems absurd, but nevertheless it is capable of being demonstrated practically as well as mathematically.

The matter first suggested itself to me some two years ago in connection with the paralleling of some alternators in which the synchronizing power was rather large. The synchronizing force in an alternator can be varied by increasing or decreasing the field current, and in consequence, the voltage of the machine, and in these particular machines which were of the two-phase type, the synchronizing force could also be greatly reduced by running the machines with only one phase connected in circuit. Some difficulty was experienced with the paralleling at the start, and a rather extensive line of experimental work was undertaken in the endeavor to locate the trouble and to overcome it. It was found that when the generators were run in single phase, they would parallel very satisfactorily, but when the second phase was cut in, the cross current would increase and quite serious transfers of energy would take place between the machines. At that time it was authoritatively denied by electrical engineers of high standing that any two-phase machine would parallel more readily on one phase than on both; now, however, I believe the fact is freely admitted.

It was further determined beyond question, that by lowering the voltage to 80% of the normal—or in other words decreasing the synchronizing force 20%, the action of the machines in parallel was not open to criticism, even when running with both phases connected up. The repetition of these experiments a sufficient number of times to determine that the observed phenomena were not accidents, but were in accordance with some fixed law, made it quite apparent that, at least over the range covered by the experiments, the difficulties in paralleling increased with the synchronizing force of the generators. Irrespective of whether a correction of the trouble could be effected by decreasing the sensitiveness of the governor, or improving the turning moment of the engine, or doing both simultaneously, the indisputable fact remains that with the original engine performance a variation of 20% in the synchronizing power made the difference between success and failure in operating the generators in parallel, and this seems to indicate the utter fallacy of specifying the same characteristics in the engine for alternators in which the synchronizing force may differ by 200 or even 300%.

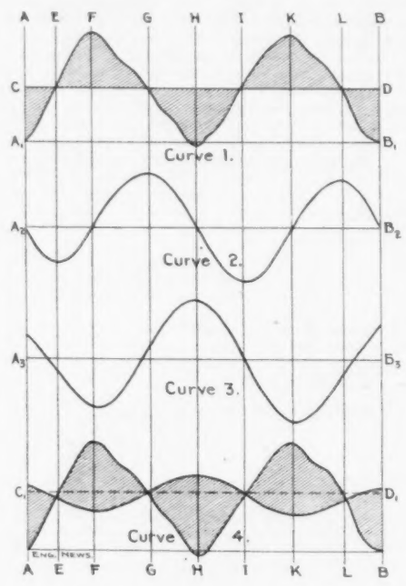
The fact that the synchronizing force does, under all ordinary conditions, increase the angular variation in the engine may be shown theoretically in a general way without recourse to any abstruse mathematics. In the accompanying figure, curve 1 represents a typical diagram of crank forces in a single-crank double-acting engine. The distance $A_1 B_1$ represents one revolution, and the ordinates of the curve shown, measured from $A_1 B_1$, represent to some chosen scale the tangential pressure on the crank pin at any point in the revolution; the area included between the curve and the base line $A_1 B_1$ represents the work per revolution in foot pounds. $A_1 C = B_1 D$ represents the mean resistance of a uniform load reduced to the radius of the crank, and neglecting friction the area of the parallelogram $A_1 C B_1 D$ also represents the work per revolution in foot pounds. The shaded portions of the area included between the line C D and the curve if above the line C D, represent in length the portion of the revolution in which energy is being stored up in the flywheel and in area, the amount of this energy in foot pounds. In like manner the shaded areas below the line C D represent the portion of the revolution in which the stored energy is being given up by the flywheel, and the amount of this energy.

While the crank is passing from E to G, the flywheel is absorbing energy and its velocity is increasing. Consequently at G, after having taken up the last foot pound of available energy, the velocity will have reached a maximum, and will then begin to decrease from G to I while the wheel is giving up energy, becoming a minimum at I; similarly other maximum and minimum points will be found at L and E. By mechanical integration of the curve in Fig. 1 referred to the base line C D we obtain a second curve, Curve 2 in the figure. The ordinates of this curve measured from the base line $A_2 B_2$ representing uniform mean velocity indicate the velocity of the crank pin above and below the mean velocity. The scale of these ordinates depends on the mass and radius of the flywheel.

Referring to this velocity curve, it will be noted that the velocity is less than mean from A to F, and consequently at the end of this period, at the point F, the crank pin will be at a maximum distance behind the position corresponding to uniform angular speed. From F to H, the velocity is above the mean, and consequently at the point H the crank pin will be a maximum distance ahead of the position corresponding to uniform angular speed, and so on. Integrating the velocity curve referred to the base line $A_2 B_2$ we therefore obtain Curve 3, the ordinates of which referred to a base line $A_3 B_3$ drawn midway between the highest and lowest points in the curve, represent the departure at any point in the revolution from the position corresponding to absolutely uniform angular speed.

It will be noted that the displacement curve, Curve 3, and the curve of crank-pin forces, Curve 1, have a general resemblance in shape, in that each has the same number of nodes; but the nodes of one curve are directly opposite to those of the other. In other words, when the crank-pin effort is above the mean and the surplus energy is *accelerating* the rotating masses, these masses are always *behind* the position corresponding to uniform angular speed, and when the crank-pin effort is below the mean and the rotating masses are being *retarded*, these masses are always in *advance* of the position corresponding to uniform angular speed.

Now let us consider the effect of the synchronizing force of the generators. For simplicity we will assume



that the engine-driven alternator is coupled in parallel with a number of turbine-driven alternators running at absolutely uniform speed, and that the total mass of these alternators is such that the synchronizing force can effect no appreciable change in their velocity. Whenever the steam-driven alternator is behind the position corresponding to uniform angular speed, the synchronizing force tends to accelerate the rotating masses, and whenever it is in advance of the position corresponding to uniform-angular speed, the synchronizing force tends to retard the rotating masses. The intensity of these accelerating and retarding forces is represented at any point in the revolution by the ordinates of the displacement curve, the scale being portional to the synchronizing power of the generator. It will therefore be readily seen that the synchronizing force acts in unison with the crank-pin force. During the period of the revolution in which we have a surplus of crank-pin effort, this surplus is augmented by the synchronizing force, and during the period in which there is a deficiency of crank effort, this deficiency is further augmented by the synchronizing force.

This may be shown graphically, as in Curve 4, in which the line of crank effort is reproduced from Curve 1, and the line of load resistance instead of being represented by a straight line is represented by a curve of the same general form as the displacement curve, indicating the change in load during the revolution, due to the synchronizing force. The shaded areas in this diagram illustrate the unbalanced forces resulting from the combination of the crank-pin and synchronizing efforts. It will be noted that the unbalanced forces are very much greater than those due to crank-pin effort alone, and as these unbalanced forces are the cause of the departure from the position corresponding to uniform angular speed, it is evident that whatever increases these unbalanced forces, will increase the variation from uniform speed.

As stated previously, the effect of the synchronizing force between the alternators is analogous to that of a spring capable of both extension and compression, and considered apart from all other forces, will produce an oscillation of the rotating masses, the period of which oscillation depends on the intensity of the synchronizing force and the magnitude of the masses. The period of this oscillation has a very important bearing on the amount the angular displacement is augmented by the synchronizing force. With a period which I believe corresponds with the time of one revolution of the engine, the angular displacement seems to be increased indefinitely. As this natural period of oscillation is increased or decreased from the critical period, the effect of the synchroni force on the displacement seems to decrease.

Of course, if the synchronizing force were infinite, would have the same effect as if the generators solidly linked together, and the actual displacement wo be the mean of the individual displacements of the eral units in parallel, and would be less than that of unit running independently. There is also perhap period of oscillation between the critical period, and an finitely short period, which would not increase the placement, and doubtless as the period decreases from point, the displacement would decrease. I have, howev at the outset limited the general proposition to practi cases and these are not practical. The rotating mas must of necessity be of such magnitude that it is impr ticable to have a synchronizing force sufficiently large cause oscillations having a period much if any less th the time of one revolution.

I shall feel happy if I have succeeded in indicating new line of investigation in connection with this troubl some problem, and shall be content to leave the investig tion itself to those who are more able to carry it out a finish.

I shall feel doubly happy if I shall succeed even in th smallest degree in making it plain to the electrical frate nity that the electrical and the dynamic features in th case are so interrelated that real knowledge can com only when the electrical engineer and the mechanical engi neer drop all petty differences and co-operate with ea other in the most frank and hearty manner. As long a one is expected to blindly and unquestioningly follow th dictates of the other, successful paralleling will be by ac cident rather than design. The whole matter is one of compromise. Let it be freely admitted that the irregularities in the action of the engine do set up electrical disturbances. The reciprocating engine will always have an irregularity in angular speed and consequently electrical disturbances are inevitable. The engine builder can control the amount of this irregularity to a certain extent but he is barred by constructional and commercial limits from reaching absolute perfection. On the other hand, the electrical disturbances react on the engine, augmenting the inherent irregularities in the latter, and the intensity of this reaction is within certain limits under the control of the electrical engineer.

It is therefore only when the engine builder and the electrical engineer each recognize the limits beyond which the other cannot go, and each endeavors honestly to make the task of the other as easy as possible, with due regard to the commercial excellence of the direct-connected unit as a whole, that we may hope that the parallel operation of direct-connected alternators will cease to be a subject for discussion.

A RAILWAY CURVE PROJECTOR AND SCALE.

Engineers need not be told that the projection of a railway location upon a plan is slow and tedious work, as laid down by straight-edge, triangle, compass or curves, with the accompanying labor of scaling lengths on the curves and locating stations. To reduce this labor and to save time, Mr. Charles H. Quimby, Jr., Resident Engineer on the Baltimore & Ohio R. R. at Confluence, Pa., has devised the curve projector and scale here described.

This projector consists of two rectangular sheets of celluloid, or other transparent material, which have inscribed upon them segmental curves of different radii, as shown in Fig. 1. On each sheet the curves begin along a common radius line C, which also forms the joining edge for the two sheets when used together. The beginning points of all the curves are spaced uniformly on this line and the value of each curve is plainly marked. Throughout its length each curve is graduated to some convenient scale, and at each 100 ft. on the curve an aperture is made through the sheet to permit marking on the map with a point or pencil.

The two sheets are exactly alike, except that on one the curves are laid off to the right and the other to the left, so that they may be joined together. To temporarily fasten the abutting sheets together one or more clamping plates of simple design are provided, as indicated in Fig. 2. The sheets may be evidently joined on the same curves, simply doubling the length, or curves of different radii may be used for compound curves.

In using this projector the sheet, or sheets, are simply placed upon the map location and the desired curve or combination of curves is then selected to suit the conditions found. When two or more points on a suitable curve have been marked on the map, the sheets may be moved forward. Mr. Quimby says that a paper location may be thus made with as much accuracy and in much

less time than when the old method is employed. Patents are now pending on the instrument, and it is expected to have it shortly on the market and available for draftsmen's use.

LIQUID FUEL FOR STEAM RAISING.*

By James W. Warren.†

The petroleum oils of Southern California are of an asphaltum base and carry about 30% of asphalt. There being little paraffin and a comparatively small amount of illuminating oil in their composition, distillation is not as general as with Eastern petroleums. The greater amount of distillation of the local petroleum is for the large quantities of asphalt it carries, this asphaltum finding a ready market here and in the Eastern States.

The liquid fuel from our local oil fields is pumped from wells within the city limits. These wells average 1,000

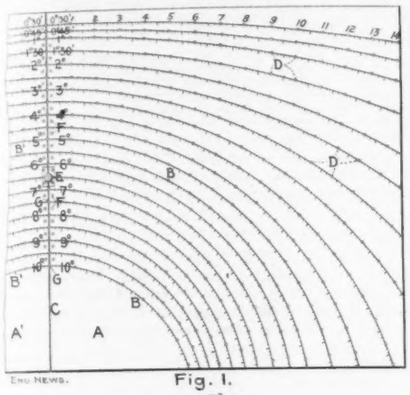


Fig. 1.

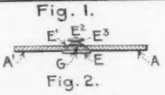


Fig. 2.

Figs. 1 and 2. A Tool for Plotting Railway Curves.

ft. in depth. The oil carries in suspension considerable sand and water, for the removal of which storage and heating are required. This oil is delivered to consumers in tank wagons of about 20 barrel capacity. When the oil is delivered to the consumer, a sample is taken from the wagon and tested for temperature, gravity and percentage of water. The average temperatur is 70° F., the average gravity 15° Beaume, and the percentage of water averages about 6% of the load in the wagon. The method of determining the amount of water in the oil is by the gasoline test. This test is made with a test tube holding 100 cu. centimeters and graduated in hundredths. The tube is filled with 50 cu. cms. of the oil test and 50 cu. cms. of gasoline. By agitating the mixture thoroughly, the gasoline cuts the envelope of oil that surrounds the globules of water in the oil, allowing the water to precipitate itself to the bottom of the tube. The percentage of water that gathers in the bottom of the tube determines the percentage of water in the load, and deductions are made accordingly.

The low gravity and high flash test of the local oil make it perfectly safe for use under boilers and in storage. Loss by evaporation due to exposure to the heat of the sun is comparatively small.

The method of handling the liquid fuel at the generating station of the Los Angeles Electric Co. is as follows: The fuel is pumped from the main storage tank to the furnace supply tank of 100 barrel capacity. In this tank the oil is heated to 80° F. It then passes to a pair of small duplex steam pumps, which give it 20 lbs. gage pressure. The oil then traverses pipes within the breeching of the boilers, which heats it to 190° F., and then goes on to the burners. The burner is of the spray type, using steam as the medium of spraying the oil. These burners consist of two circular disks, 1½ ins. diameter, slotted, and arranged in such manner that the oil, fed by separate pipe to the lip of the upper disk, meets the steam at its orifice just under this lip. This steam forms a fantail spray, which breaks up the oil into particles sufficiently small to ignite immediately by the heat of the brick lining of the furnace and the layer of bricks upon the grate bars.

Each one of these burners has an evaporation efficiency of 3,000 barrels of water per hour from and at 190° F. The sound of combustion produced by these burners is comparatively soft. The flame fills the furnace-box, covering the entire furnace-box sheets of the boiler. This gives active heat action to all of the evaporative service of the fire sheets without unduly heating any one particular portion, and at the same time perfect combustion is taking place, as denoted by the absence of any colored gases leaving the stack.

If economy in the use of liquid fuel is to be considered, a high-temperature thermometer in the smoke stack is as necessary as a water gage glass on a boiler, for by the thermometer only can the fireman graduate the amount of air necessary for perfect combustion. As a test of this, our fireman can raise the temperature of the gases in the stack from 450° to 600° F. by closing the ash-pit doors 1 inch. By the use of the thermometer the fireman can so regulate the burners under each boiler that it will do its proportionate amount of work. This is very essential in plants working many boilers set in batteries. It is an important point that the evaporative efficiency of the burners should be kept as high as possible; that is, the burner that consumes 5% of the steam which it evaporates should not be allowed to consume 20%, which it might do if not judiciously controlled.

The evaporative efficiency of oil as compared with the same weight of our average good steam coal is 28% higher than that of the coal.

There is a saving of 75% in the cost of paint, waste, brooms, tube cleaners, etc., required in the everlasting removal of coal dust, dust from ashes, soot, etc. The use of liquid fuel solves the smoke problem, as smoke issuing from a stack where oil is used for fuel is an evidence of improper combustion and can be avoided.

If required to raise steam rapidly, the fireman can do so without endangering the burning out of his boilers as greatly as when coal is used. On the other hand, if for any reason it is necessary to shut the fires off immediately, it can be done without the annoyance and danger of pulling out a heavy fire from the furnace.

By H. T. Edgar.‡

To the people of Texas, the fuel oil question is one of vital importance, and will undoubtedly do more to increase her manufacturing interests than any other one industry within her borders.

Fuel oil was discovered at Beaumont in January, 1901, and up to the present time there are about 220 wells (6 and 8-in.), most of them being from 1,000 to 1,050 ft. in depth. A great many of these wells are gushers, but it is only a question of time when the oil has to be pumped, and all of the wells will sooner or later become pumping propositions.

BURNERS.—Experiments have been made with two burners—a straight-blow burner and a cross-blow burner. Thus far we have been unable to see that one has any special advantages over the other as regards economy or ease of manipulation. In the straight-blow burner there is a central brass casting with a small bore through which the oil passes. The outside of this casting is fluted like the rifling of a cannon, and outside of this is another brass tube. The steam passing through this space and the fluting, gives it a whirling motion, so that as the oil flows out of the inner bore it is caught by the whirling steam and atomized. It is considerable work to set this burner in place, as there are many changes to make in the brick work of the furnace. In order to atomize the

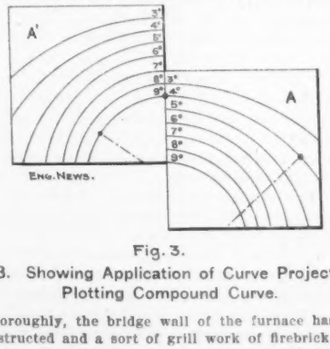


Fig. 3.

Fig. 3. Showing Application of Curve Projector for Plotting Compound Curve.

oil thoroughly, the bridge wall of the furnace has to be reconstructed and a sort of grill work of firebrick put in its place. The grate bars are lowered about 12 ins. in the firebox, and a double row of firebrick laid on top in such a manner as to form an air chamber between them, through which all air must pass in order to reach the furnace, the idea being that the air becomes heated before coming in contact with the fire. There are two of these burners under each boiler, each one being set in the fire door, and the door bricked up solid, except a small hole for looking into the furnace. When once set up, it is rather difficult and expensive to change back to coal.

The cross-blow burner consists of a small casting with an overhanging top perforated with small holes arranged in a semicircle on the under side. Just below these holes is a slot in the burner through which the steam issues in a sheet, and the oil being forced through these holes comes in contact with the steam and is atomized. This burner is put through a hole between the fire doors, using only one burner to a boiler. The grate bars are left in the same position as when coal is used, and are covered with a layer of firebrick laid in mortar. These bricks cover the entire grate except a few inches in front for air, and the bridge wall is left as used for coal. The furnace doors remain unchanged.

To convert a furnace from coal to oil will take from two to three days, and to convert to coal again from two to three minutes, where the cross-blow burners are used. After being once equipped for oil, however, and then converted to coal, it could be reconverted to oil again in about one hour.

In the use of fuel oil it is necessary, in order to get economical burning, to have the oil flow to the burners at a steady pressure. Our first experiments demonstrated the necessity of this, as our fires were often put out through unsteady pressure. With a steady pressure of steam at the burners, if the oil pressure decreases, the steam is likely to blow out the fire, while if it increases, more oil comes through the burners than could be properly atomized, the result being (1) the fire smokes badly; (2) the excess oil runs away in the ash-pit, causing liability to explode; (3) it fills the tubes with a soot that is much harder to remove than coal soot; (4) the oil that is not atomized and flows away is lost.

In order to insure a steady pressure of oil, it is necessary to provide an auxiliary air chamber. Connected to this air chamber is a small safety valve, which, in case the pressure runs above the point required, returns the excess oil to the storage tanks.

To start the burners, it is simply necessary to turn on the steam and a small supply of oil and throw a piece of burning waste into the firebox, and we immediately have a full fire. To regulate it properly, it is necessary to adjust the supply of both steam and oil until the fire burns without any smoke; and if properly regulated we get a complete combustion of the oil and avoid almost entirely the presence of soot in the tubes and smoke from the stack. It is also possible, by simply increasing the supply of both steam and oil, to force the boiler to any extent. Care must be taken, however, in selecting burners to get one that thoroughly atomizes and distributes the oil so as not to confine the fire to any one part of the shell and burn the boiler.

The boilers are provided with peep holes in the back to enable the fireman to see the condition of his fire. Care must be taken to watch the fires very closely, and in case they go out for any reason to shut off the oil immediately, as the gas from the oil, combined with the air in certain proportions, is very explosive. Cases of this kind have been known where an explosion has occurred which took the damper up the chimney and blew out the front of the boiler.

In installing this apparatus, it is necessary to comply with certain rules and regulations of the insurance companies in order to prevent an increase in insurance rates. These rules, however, are not in any way unreasonable, but are necessary to afford ample protection to the plant. Their principal requirements are as follows:

(1) The storage tanks shall be buried 4 ft. underground and 10 ft. from the building; or, if located more than 100 ft. from the building, may be put above the ground or only partially buried, in which case they must be surrounded by a brick or earth embankment forming a reservoir of sufficient capacity to hold double the contents of the tank.
(2) They must have a gas-tight manhead at the top.
(3) They must not be filled in excess of 98% of their capacity.
(4) They must have a 2-in. vent pipe.
(5) The highest point in storage supply must be at least 2 ft. below the level of the furnace where oil is to be burned, thereby preventing gravity feed to the boilers.

Experiments have been made by the water-works companies at El Paso and some very accurate figures have been obtained. The results of these tests show that the cost of burning fuel oil is exactly half the cost of burning coal, the coal costing $5 per ton, and fuel oil costing 70 cts. per barrel. The coal used prior to the installation of fuel oil was San Antonio coal from New Mexico.

THE FIREPROOFING OF STEEL WORK IN BUILDings was recently the subject of an interesting legal decision in Germany. The police authorities of the city of Hanover had ordered that the exposed structural ironwork in a certain new building must be protected with fireproofing. The owners of the buildings sued against enforcement of the order, but they were defeated in the original suit as well as in final appeal. The jurisdiction of the police authorities in the matter is established by the lack of any provision regarding fireproofing of steel work in the building regulations of the city. It appeared from expert testimony that at temperatures of 600 to 800° C., as are realized in fires, the steel columns and beams were weakened, and would allow the building they carried to collapse; further, that surrounding the ironwork by protecting material would prevent such overheating in case of fire. The lower floors of the buildings in question were for store and warehouse use; the upper stories were used as living rooms. These conditions created a possibility of conditions of danger which justified the order issued by the police authorities. One contention of the plaintiffs was that the order would only be justified if necessary to prevent or correct actual, not merely possible, conditions of danger, and that it must be shown that the danger would be immediately impending if the police did not interfere. The court held that the danger need not be thus immediate, but that the order was justified if there was a reasonable possibility of the danger arising.

*Abstract of a joint paper by J. W. Warren and H. T. Edgar, presented by title at the convention of the National Electric Light Association, Cincinnati, May 20 to 22.

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ADVERTISING RATES: 20 cents a line. "Want" and "For Sale" notices, special rates, see page XXIV-XXIX. New copy for standing advertisements should be received one week in advance of publication; new advertisements, Monday morning. The pages containing "Want," "For Sale" and "Proposal" advertisements are held open until Wednesday noon.

We supposed the Intercontinental railway scheme was dead, but it seems from the May "Bulletin of the International Bureau of American Republics" that a little life was injected into its corpse at the Pan-American convention held in Mexico last fall. Many of our readers may have forgotten what the Intercontinental Railway scheme is. It was born a dozen years ago, when the first Pan-American conference was held in Washington. The proposition, then and now, is to connect the railway systems of North and South America by building a railway through Central America, together with the filling of such gaps in the South American systems as would furnish continuous railway communication from the United States to the seaports of Southern Brazil and the Argentine Republic.

Surveys, or better a preliminary reconnoisance was made by engineers over the whole line, and was completed in 1895 at a cost of about $360,000. This showed that the construction of about 5,000 miles of railway would be necessary, and its estimated cost was about $200,000,000.

The Pan-American conference of last fall resuscitated the project from several years' sleep and adopted resolutions inviting the United States to push the project ahead by sending agents to the various countries to investigate the commercial prospects of such a railway. A committee was also appointed with instructions to further the enterprise by all possible means, and particularly to convene within a year representatives of all the countries interested to arrange for the construction of the proposed railway. The members of this committee are ex-Senator H. G. Davis, Mr. Andrew Carnegie and the representatives of Mexico, Peru and Guatemala at Washington.

Congress has been asked to appropriate $20,000 for the purpose of sending two commissioners to study the commercial conditions and prospects of such a road. If two men could be sent who would make a fair report on the matter, such as they would make for a banking house, with no spread-eagle business, we judge the $20,000 would be well invested.

Mosquito extermination may yet afford a new field for engineers. Much has been said of late about the anopheles mosquito as the sole agent in the spread of malaria, and it is well known that both the anopheles and culex, or more common form of the pest, must have water for breeding purposes. It having been found that a thin film of crude petroleum over a mosquito-breeding pool will put an end to the nuisance, numerous communities have been spraying ponds and pools with that substance. In some localities private citizens have been stocking such waters as would support them with fish that feed on mosquito larvae, goldfish being highly recommended for the purpose. To an engineer, and likewise to any other practical person, the most obvious mode of eliminating mosquitoes is to remove every possible breeding place by either (1) doing away with the breeding places by filling or draining low places or (2) regulating streams and ponds so there will be no stagnant bays and adjacent pools, swamps or marshes to foster the larvae. Doubtless much work of this character has been done on a small scale, but in many sections of the country, particularly where tidal marshes and large fresh water swamps abound, nothing short of concerted effort on the part of landholders and municipalities alike can successfully accomplish the task. So far as we know, the first attempt at a wide co-operative scheme has been carried on by the North Shore Improvement Association, of Long Island. The association has just issued an important report on its work, which includes the results of surveys and estimates by its engineer, Mr. Henry Clay Weeks, Bay Side, L. I., a report on marsh reclamation by Prof. N. S. Shaler, of Harvard, and reports by several entomologists, as noted in more detail elsewhere in this issue. As a whole, the volume in question indicates where mosquitoes are breeding, tells whether filling in, draining or the mere clearing of shores is advisable, and gives estimates of cost for each case. In some instances, stocking with fish is advised, and in all cases it is understood that water surfaces will be sprayed with oil periodically, so far as practicable, until more permanent measures have been carried out. During 1901 some drainage work and diking was done on Center Island, Oyster Bay, under Mr. Week's direction. Of course, for every opportunity to do any remunerative professional work in the way of mosquito extermination engineers are likely to have a hundred chances to make suggestions or give specific advice to local property-owners and boards of health. A hint dropped here and there, an occasional letter to a local newspaper and an appeal to the town or city board of health to adopt permanent rather than temporary measures of relief may result in much good. Engineers, like physicians, owe the communities in which they reside special consideration in matters relating to the public health, since men in both professions are by training and experience peculiarly fitted to give counsel in sanitary matters. This does not mean, in either case, that professional services are to be rendered gratuitously, except in so far as each citizen is bound to contribute some of his powers for the common good of the community he has chosen for a home.

The advantages of a meter system, particularly where all the water is to be purified, are recognized by the Pittsburg "Dispatch," which is urging the officials of that city to modify the filtration plans so as to provide only such an amount of water as would be required under a full meter system. Some utterances of the "Dispatch," a few weeks ago, led us to believe that it did not realize the necessity of providing filtering capacity for the maximum daily consumption, and that it was basing its arguments for a reduction in the size of the proposed new purification works on the average daily consumption instead. Accordingly, in our issue of June 5, after commenting on the opposition by the Philadelphia "Ledger" to the introduction of meters in that city, we criticised "one of the Pittsburg dailies" for the assumption outlined just above. In its issue of June 7 the "Dispatch" asserts that its attitude has been misrepresented, and states its position as follows:

> Taking the report of Mr. Allen Hazen that under meter system the average daily consumption of the population supplied by the Pittsburg water-works would be 15,200,000 gallons at the date of the report, or now at the same rate of about 70 gallons per capita, probably 17,500,000 gallons, and finding this estimate corroborated by the experience of cities where the meter system has been in operation, the "Dispatch" has opposed the construction of a filtration plant with a capacity four or five times that consumption. It has advocated instead the construction of a plant of 35,000,000 to 40,000,000 gallons capacity, with land enough to permit the extension of the plant as population increases until it could supply a population of 2,000,000 with the water waste prevented. In short, it proposes a surplus capacity over an economical consumption of 50 to 75%.
>
> Since the Engineering News asks how long a daily newspaper could run if its capacity were limited to its average business we will respond by another question. What would it think of a business enterprise which insists on building a plant four times as large as its business needs when it had only money enough to pay for a plant of half the size?

Whatever the "Dispatch" may have said in the past, the general principle which it is now maintaining is correct; that is, waste restriction and water purification should go together, or, rather, restriction should precede purification. Mr. Hazen's idea, as expressed in the Report of the Filtration Commission, was to install meters gradually, so the reduction in waste would keep pace with the legitimate increase in consumption, thus rendering "a filter plant suitable for the present consumption" sufficient for 25 years to come. Unfortunately, the Pittsburg authorities did not see fit to begin the installation "at once," as Mr. Hazen advised. Moreover, after a lapse of three years, nothing to that end has been accomplished, and meanwhile the consumption and waste has been mounting up. Worse still, no plans appear to be under way for beginning to put in meters in advance of constructing the settling reservoir and filter beds. While, as already said, the general principle now advocated by the "Dispatch" is correct, the practical question is, what can be accomplished under existing conditions? With the most stringent measures, how nearly and how rapidly can a great manufacturing city, after years of prodigal water waste, approach 70 gallons per capita per day? If the reform element in the city government proves itself as wise in its methods as it is zealous in its aims, it will speedily proceed against water waste and give less occasion for saying that it is opposed to filtration. At the same time it must show caution in its assumptions regarding the effect of waste prevention on the safe capacity of the filters.

PROGRESS TOWARD SAFER RAILWAY OPERATION.

For many years, the record of accidents has been a serious blot upon the general record and reputation of the American railroad system. We carry freight long distances at a fraction of the cost of such work in any other country. Our passenger service is the envy of all other nations for its luxurious appointments; but the number annually killed and maimed on our railways forms a ghastly record of casualty, of which little can be said in extenuation.

The Interstate Commerce Commission, in its Fifteenth Annual Report, just issued, prints a summary showing the deaths and injuries in the past 13 years on the railways of the United States. The number of persons killed during this period was 86,277, and the number of injured was 469,027. Thus, in this comparatively brief period more than half a million persons suffered death or injury from railway accidents. This is a population greater than that of any city in the United States except the six largest. It is a greater population than that of 18 States of the Union.

Of the fatalities by rail, nearly three-fourths occurred to persons who were neither employees or passengers, the number being made up chiefly, of course, of those who are trespassers on railway tracks, or who cross the tracks at highway crossings. Of the persons injured, however, the

great bulk is made up of the railway employees in freight train service, and as has long been well known, the most fruitful agent in producing these injuries for many years was the old link-and-pin car coupler.

Nine years ago, in 1893, Congress passed a law requiring the equipment of all cars in railway freight service with automatic couplers, and the use of air brakes on all freight trains, and after some delays and extensions of time the work of equipment was practically completed in August, 1900. It becomes of much interest to inquire what the results have been from this legislation in the way of reducing accidents. Various conflicting statements have been published concerning the matter, and it has even been claimed that the troubles and accidents with the present automatic couplers exceed those which were experienced with the old link-and-pin drawbar. For the actual facts, however, reliance must be placed on the official statistics collected by the Interstate Commerce Commission, and these are presented in the Fifteenth Annual Report of the Commission, just issued. These show, to sum up briefly, that the fatality among freight train employees appears to be about 35% less in the year ending June 30, 1901, than in the year immediately preceding, while the percentage of injuries was reduced about 52%. These official statistics are corroborated by reports from the claim departments of railway companies, and from the officers of railway employees, organizations which pay benefits to their members who suffer death or injury in the service.

Besides this convincing testimony that automatic couplers and air brakes have saved lives and limbs, there is equally convincing testimony that their introduction has made possible enormous economies in railway operation. With the old link-and-pin coupler and hand-brake, it would not be possible to successfully operate the long and heavy freight trains which are common at the present day, nor would it be possible to carry on the yard work as rapidly as is now done. The statistics collected by the Commission show the average freight transportation work done per trainman employed in 1893 and in 1900, and the comparison is as follows:

	1893.	1900.
No. tons carried for each trainman employed	5,085	7,107
No. tons carried 1 mile for each trainman employed	638,635	913,425

If we look at the railway as a machine for producing transportation, its output is best measured in ton-miles. On this basis it will be seen that the average output per employee in freight train service has increased nearly 50% in the past seven years. This has been due, of course, to the increase in weight of freight trains; and this increase, as we have just seen, has been made possible by the use of air brakes and automatic couplers.

It is of some interest to recall at this time that exactly this result was predicted nearly thirteen years ago by the late A. M. Wellington, in an editorial published in our issue of Dec. 21, 1899, entitled, "The Money Value of Good Freight Brakes and Couplers." In that article it was predicted that the equipment of freight cars with these devices would be accompanied by an increase in freight train speeds and also by an increase in the weight of freight trains. Mr. Wellington even gave an estimate in figures of the economy which would thus be effected which we quote in part as follows:

> We believe it to be a most conservative estimate that at the very least this increase of train load will average 20% throughout the United States, and on very many roads or divisions will be over 50%. . . . Now an increase of 20% in train load means a saving of about 10% in the total cost of transportation.

How remarkably this prediction has been verified, all our readers familiar with railway matters are, in a general way, aware. To exhibit actual figures, however, we may note that the average freight train load, according to the Interstate Commerce Commission's statistics, has increased from 175.12 tons in 1890 to 270.85 tons in 1900, an increase, not of 20%, as predicted by Mr. Wellington 13 years ago, but of 55%.

Turning again to our main theme—the reduction of accidents in the railway service—it is to be said that while a substantial reduction in casualties has been effected, very much remains to be done to bring the record down to where it should be.

Railway officers, unfortunately, are a bit inclined to look on train wrecks and casualties among the operating force as a sort of necessary evil. It may be wholesome in this connection to reflect that on English railways—of whose alleged "decadence" so much has been heard during the last few years—not a single passenger met death in a train accident during the year 1901. With such records made elsewhere, it is absurd to look upon our present large rate of casualties in the railway service as irremediable. An accident means, almost invariably, a blunder somewhere, wrong appliances, wrong methods of operating, defective discipline. These are not to be remedied in a day, of course. The habits formed in the old happy-go-lucky days of running trains are slow to eliminate from the operating force; but progress is all the time being made in the direction of greater safety and reduction of accidents.

As evidence of the decreased risk of injury resulting from a single safety appliance, it may be noted that whereas in 1893 one trainman out of every 13 received an injury in coupling and uncoupling cars, in 1900 only one out of every 30 received an injury of this sort.

This reduction, however, is but a small percentage of what should and doubtless will be attained. The Commission, in its report above referred to, devotes nearly 50 pages to the subject of safety appliances, and points out forcibly, the further improvements in brakes and couplers and in systems for their inspection and maintenance which ought to be made. Many of these have been advocated in the columns of this journal, such, for example, as the elimination of the link-slot in the knuckle of M. C. B. couplers.

In this connection, also, the Commission pays a well-deserved tribute to the Master Car Builders' Association, and the American Railway Association for their work in furthering the application of Safety Appliances on the most favorable lines, and we trust this may not be without influence in influencing further action by these organizations.

The fact is, that all that has been done for the introduction of safety appliances through national legislation ought to have been done, and we believe might have been done by the railways themselves.

The Safety Appliance law enacted by Congress in 1893, was opposed by every influence that the railway companies could bring. The journals devoted to railway interests, with the single exception, so far as we recall, of Engineering News, joined in the opposition. The law was passed, nevertheless, chiefly through the influence of the railway employees' organizations, and we are glad to say that many of the railway officers who were strongest in opposition have the candor to admit now that it has been of very great benefit to the railways, not only because of the saving of lives and limbs, but because of the economies which it has made possible in railway operation.

Cannot the lesson of experience be heeded? Congress enacted legislation in 1893 which would have been unnecessary if the associated railways themselves three or four years earlier had taken such vigorous action for the application of brakes and couplers as their own interests demanded.

The situation to-day is not dissimilar. Further and radical action is needed on the part of the railways to eliminate the troubles now experienced with brakes and couplers. Already Congress is being besieged for further legislation on this matter, as our correspondence columns have recently shown. If the railways will take the action which their own interests demand, there will be no need for further legislation. If the railways adhere to a policy of delay and obstruction, then further legislation from Congress may be expected, and it may very likely be framed on less prudent and conservative lines than in the past.

We are well aware of the difficulties in the way of action. The Master Car Builders' Association is not vested with the official power and authority which it should possess; and the financial heads of railways do not understand as they should the great importance of authoritative and practically compulsory action by the railway associations on matters that affect their common interests.

Nevertheless, the world does move. The recent adoption by the American Railway Association of a standard box car and of the per diem system of payment for foreign cars, is the best of evidence that action is now possible for the prosecution of reforms that was impossible but a short time ago.

With such evidence as this we may turn to the black and dismal record of railway accidents—which shows a total of over 50,000 per annum, in the whole United tSates—not in despair, but in confident assurance that the future is to see rapid progress toward safer railway operation.

LETTERS TO THE EDITOR.

Concerning Strikes.

Sir: In your issue of June 12 is an editorial "Concerning Strikes" which will be read with care and interest, but does it not leave us in the air? Your presentment of the status of things is excellent—but what of the future? Here disappointment awaits us. You promise nothing "until both labor and capital are BROUGHT BACK (capitals are mine) to a sound economic basis.

No, neither the world, nor the great events destined to be evolved thereon, *moves backward*. What one generation of essayists have thought to be "sound economic" principles, another has cast into oblivion. Often events grow faster than chroniclers can keep pace with them, or logicians can correctly analyze them. Something of the seer will be required to interpret the rapid changes going on in the industrial world. One should see at least that the events of the last 50 years point to a future unknown, rather than to the known past.

If I may suggest a line of thought which might lead us in the right direction, it would point towards the principles underlying the popular movement (and its resultant conflicts) for municipal ownership of public utilities. Coal is almost as great a public and private necessity as water, and this coal strike affords us an excellent object lesson of the principle of private monopoly of public necessities.

If self-preservation be the first law of nature for the individual, is it less so for the public life?

A. F. Nagle.

Lockport, N. Y., June 16, 1902.

Sir: Allow me to compliment you sincerely on the wise and truthful editorial in to-day's issue of Engineering News "Concerning Strikes." It hits the nail on the head exactly. Truer words were never written than you use in that editorial where you say that "fair wages are such wages as *free* competition in the purchase and sale of labor would fix." (The italics are mine.)

Free competition, both in the production of coal and the "sale of labor," would settle this coal strike and free competition in production and in the sale of labor in all industries would settle all strikes.

Free competition, then, is a desideratum which the state should seek. I here use the word state as a synonym of the governing power, national and local combined.

No more intelligent, useful and hard working class of citizens in our community exists than the civil and mechanical engineers and those closely affiliated with them, to whose business and interests your journal addresses itself, and no more useful study could be proposed to them than that of the great industrial problem spoken of in your editorial, the difficulties created by which are constantly occurring in their walk of life, compelling some sort of compromise arrangement in order to allow of the more or less interrupted pursuit of their arduous avocations.

Your editorial proposes no remedy. Yet there must necessarily inhere in the state a power to cure this evil of competition, one-sided and destructive, brought about by the very men who by their pools and combinations of capital now command the situation and sneeringly remark: "We have nothing to arbitrate." Let the state examine whether it gets its full dues in taxation from these holders of coal lands and users and promoters of public franchises.

Is there a fair proportion between the sums they pay in taxation and the values of the lands they hold and the privileges and franchises they enjoy and from which, if report speak truth, they derive income running into the tens of millions per annum.

Your editorial hints at this, in a guarded way. Nevertheless, Mr. Editor, this is the solution, the key of all the difficulty. For by evading taxation these monopolists exist and cannot exist without it. By this evasion they pile up millions and shift the burden they should carry to the shoulders of the toiling workers.

Let the state reverse the process. Place the weight of

taxation upon land and franchises in accordance with their market value, thus liberating labor and trade from governmental interference; and wages, under free conditions would regulate themselves, opportunities now closed be thrown open and strikes would be unknown.

Respectfully,
A. J. Steers,
Secretary Carlin Contracting Co.

(0 Liberty St., New York City, June 17, 1902.

(The franchise tax is good so far as it goes, but it seems to us that it does not go far enough. Already, in many States, the entire State expenses are raised by special taxes on corporations, and a tendency has arisen in consequence to extravagance in State expenditures. The average legislator reasons that since the State revenues come out of rich corporations anyway, the ordinary taxpayer and voter will no longer care how they are spent or misspent.

Our correspondent says that we proposed no remedy in the editorial referred to; but a remedy has been frequently suggested in these columns for the evils of monopoly, and it appears to us that conditions are working all the time toward its ultimate acceptance. It is, in brief, that in all industries in which a monopoly becomes established, the Government—National, State or Municipal—should take part in their management by the appointment of part of the directors of the corporation holding the monopoly. Further, such corporations should be so controlled and the prices for their product should be so regulated by the management that the profits should be just sufficient to pay a fair return on the capital actually invested in the enterprise.

We know well the objection that will be raised to such a plan. It will be claimed that it would be a monstrous injustice to the stockholders of such corporations. But would the actual stockholders be really any worse off than they are under present conditions? Would they not stand a good chance of better and honester treatment than at present? How much voice does an ordinary stockholder in any of the great monopoly-holding corporations have in the choice of directors at present? How many of these huge corporations in the past twenty years have been deliberately wrecked by the inside management for the purpose of beating the stockholders out of their property?

With a full knowledge of the evils and shortcomings and defects of representative government, we are of the opinion that the small stockholders' interests would be quite as safe in the hands of a director appointed by a Mayor or a Governor or a President as in the hands of one picked out by the managers of a Wall St. syndicate, or the leaders of a "blind pool."

The reader may ask what this has to do with strikes. It has this much to do with them, that when the labor monopolies see the monopolies of capital brought under obedience to law, they will be then far more likely to obey the law themselves. Besides this, the reduction of monopoly profits to a reasonable scale will be equivalent to an increase of wages to the workingmen, for which they are now contending.—Ed.)

Steel Wheelways for Wagon Roads.

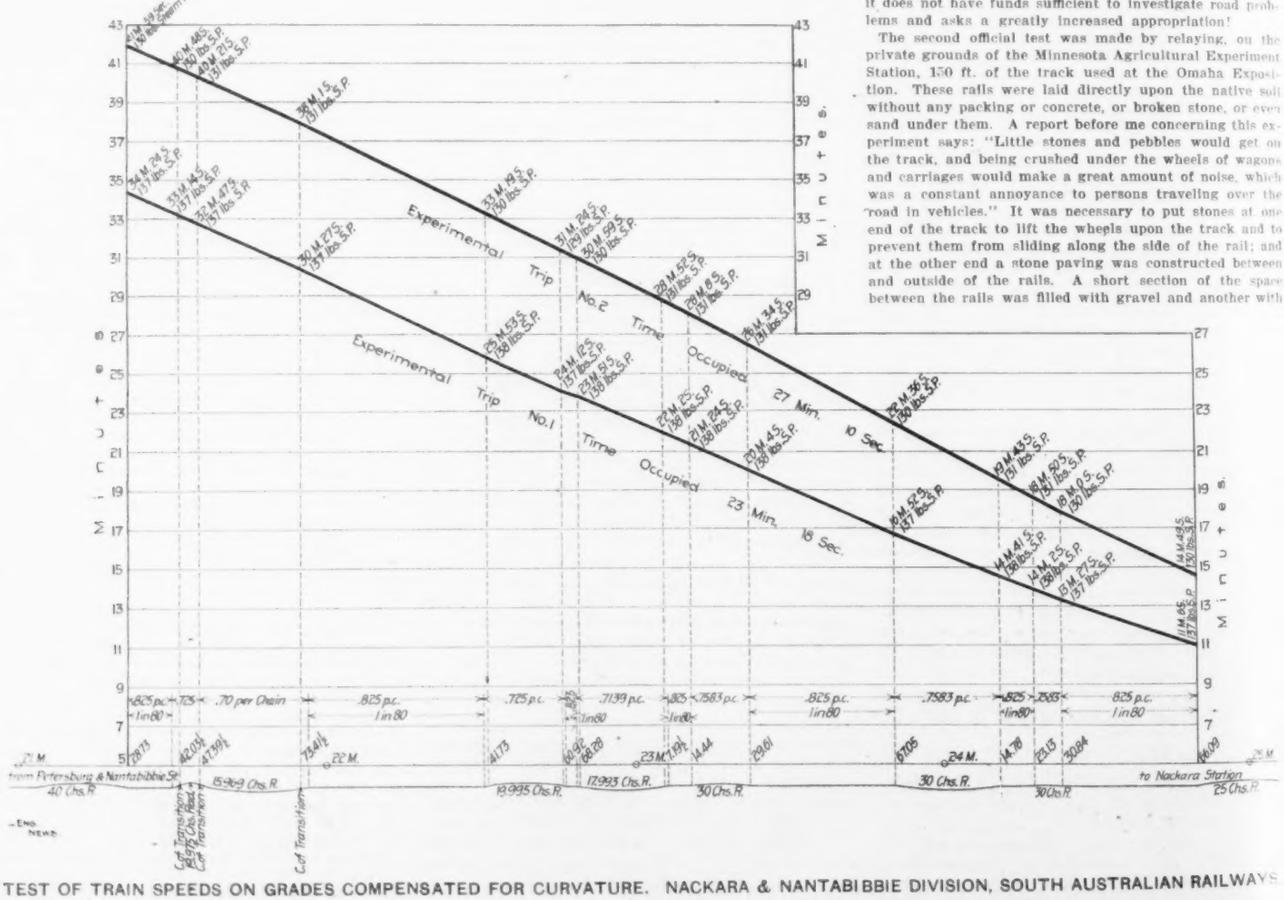
Sir: In Engineering News of June 5, the Acting Director of the U. S. Office of Public Inquiries says he cannot understand why the undersigned should have described an unofficial test of a steel wheelway instead of the "more successful experiments outlined and discussed in the Yearbook." The editorial note appended to the above communication makes it reasonably clear why one experiment was chosen instead of the others. However, as the writer has some facts concerning the "official tests," which have not been made public, possibly it is permissible to consider the subject further, particularly as the Acting Director seems aggrieved at the omission of the official experiments. The writer had all the following facts before him when preparing his former discussion, but did not present them out of courtesy to the Road Inquiry Office and because he believed the experiments to be comparatively unimportant. If the Road Inquiry Office considers these experiments so important, why was it allowed nearly four years to pass without describing the results of experience therewith, particularly as the Office has in the meantime sent out numerous circulars, bulletins and reports?

The U. S. Road Inquiry Office has made three official experiments with steel wheelways. The first was on the grounds of the Trans-Mississippi Exposition at Omaha, where was laid a steel wheelway 330 ft. long, apparently of the form described in the article in Engineering News of May 8, except that the account in the Yearbook does not make clear the kind of material under the channel. The implication in the official report is that the rail was embedded in concrete; but the direct statement is that the two other pieces (referred to below as the second and third official tests) "were made after the same pattern and style of the Omaha road," while these surely had no concrete bed.

The Acting Director in answer to an inquiry by the writer said he was unable to tell upon what material the rail in this experiment rested, or how concrete could be placed under the channel as implied in the official report. The wheelway was designed in the Office and yet the Office can not tell how to erect it!

Apparently the only tests made on this track was to draw 11 tons on three wagons with one horse. It is not stated whether the track was level or not, or whether the tractive resistance was 4 lbs. or 40 lbs. per ton. The writer had this "experiment" in mind when he wrote: "A short section well cared for on dry ground under an experimental wagon gives little or no indication of the result under the ordinary conditions of actual service." The only conclusion drawn from the above experiment in the official report was to compare a picture of one horse hitched to a load of 11 tons on 12 wheels on this track, with a picture of 20 horses hitched to a 11-ton load on four wheels on an "ordinary road." It is not stated whether the 20 horses were required to draw the load on the level or up a grade; and it is not stated whether the 20 horses pulled with all their might. And yet this same Office of Public Road Inquiries frequently complains that it does not have funds sufficient to investigate road problems and asks a greatly increased appropriation!

The second official test was made by relaying, on the private grounds of the Minnesota Agricultural Experiment Station, 150 ft. of the track used at the Omaha Exposition. These rails were laid directly upon the native soil without any packing or concrete, or broken stone, or even sand under them. A report before me concerning this experiment says: "Little stones and pebbles would get on the track, and being crushed under the wheels of wagons and carriages would make a great amount of noise, which was a constant annoyance to persons traveling over the road in vehicles." It was necessary to put stones at one end of the track to lift the wheels upon the track and to prevent them from sliding along the side of the rail; and at the other end a stone paving was constructed between and outside of the rails. A short section of the space between the rails was filled with gravel and another with



TEST OF TRAIN SPEEDS ON GRADES COMPENSATED FOR CURVATURE. NACKARA & NANTABIBBIE DIVISION, SOUTH AUSTRALIAN RAILWAYS.

Formula used in compensating grades for curvature was:

Rise (in ft. per chain) on a curve whose radius is R chains = Rise upon a tangent less $\frac{2}{R}$. For a 4-ft. 8½-in. gage line the constant in this formula would be $\frac{2.69}{R}$.

Trains tested were heavily-loaded ore teams. The weather was good, but there was a little more wind against the second trip. The rails were dry and the track in good order.

...es to make a better footing for the horses. The writer ... not think it worth while to make any investigations ... the amount of travel over this piece of track, since ... laid in private grounds the traffic must have been ... small—possibly only an average of a vehicle for each ... day. After a short time the wheelway was taken up ... no one has been found to say a word in its favor. ...ally "the greatest objection to this road is its excessive ...

...he third official test was made by laying at the Iowa ...ultural Experiment Station the remaining 180 ft. of ...maha track. A man of acknowledged intelligence ... is thoroughly conversant with this experiment writes: ...he use of this road on the college grounds has not ...ranted a favorable opinion concerning this method of ...construction; and from what I have seen of its opera... I have very great doubts about the efficiency or ...licability of that system of road making with any ... of steel track. Personally I do not believe it has ...ficient merit to entitle it to much consideration.

...of the last two experiments, the Director of the U. S. ...e of Public Road Inquiries (page 293 of the 1898 Year-...k) says: "Reports so far received from these two ...ions indicate that the two sections are coming up to ...the highest expectations." The undersigned had this re... in mind when he wrote: "Another significant fact ... that the only public account there is of some of the ...more important official experimental sections, was made ...two or three weeks' after the road was completed, and ...when it had been subjected to only a very light traffic ...during a dry time."

These above are "some of the more successful experi...ments," for the omission of which in his original article ...the undersigned has been criticised. Yours truly,

Ira O. Baker.

Champaign, Ill., June 13, 1902.

Grade Compensation for Curvature on South Australian Railways.

Sir: The compensating of railway grades on curves has received some consideration in this state. The attached diagram shows the result of our last experiment, which was very successful and may be of interest to the profession.

The gage of the new line is 3 ft. 6 ins.; the ruling grade is 1 in 80, or 0.825 per chain. The length over which the trial was made was about 3½ miles. The curves vary from 16 to 30 chains radius, the chain being 66 ft. Transitions are laid in between the main curve and the tangents in all cases where the curve is below 30 chains radius.

The experiments were made with heavily laden ore trains. The locomotive boiler pressure was in one case 138 lbs., and in the other 131 lbs., and did not vary during the experiments more than 2 lbs. The observations were taken from the middle of the train. As will be seen from the diagram, the rate of speed was practically uniform in each case. The formula upon which the compensation of the grade on the curves was based is shown on the diagram. This formula has been in use for some time on the 3-ft. 6-in. gage lines of this state.

I am, sir, yours, faithfully, Alex. B. Moncrieff.
Engineer-in-Chief, M. Am. Soc. C. E.

Adelaide, So. Australia, March 3, 1902.

(We reproduce herewith the diagram accompanying the above letter. While the curves indicate a very uniform resistance over the whole line, it appears to us that a much better way to test it would be with trains running at a speed of not more than five to ten miles per hour. Variations in the resistance of the road would be much more evident in such a test.

Really the main object in compensating maximum grades for curvature is to avoid the stalling of heavy freight trains in climbing such a grade. It has become so much the custom in recent years to compensate grades for curvature that very possibly some needless work of this sort has at times been done. The best exposition on the subject of grade compensation that we know of is Chapter XVIII. of the late A. M. Wellington's "Economic Theory of Railway Location." So valuable is it that we venture to reprint here the summary of ten practical conclusions with which the chapter closes, and trust it may prove a serviceable guide to some of the younger generation of engineers who are following the custom of compensating curvature according to some hard and fast rule.—Ed.)

1. With short grades or under favoring topographical conditions compensate as liberally as possible up to a maximum at special points of 0.10% per degree.

2. Where speed may sometimes be very low, and hence invariably on or very near to known stopping-places, this maximum rate appears, with our present knowledge, none too much. In general, however, 0.05% per degree (= 1 lb. per ton) is an ample equivalent for curve resistance, and for fast trains alone probably 0.02 to 0.03% (= 0.4 to 0.6 lb. per ton) is sufficient to balance the resistance.

3. On sections where curves largely predominate over tangents it is particularly desirable to have ample compensation, and if excessive it will do least harm. On the contrary,

4. On sections where the amount of curvature is small it is less important to have full compensation, and if excessive it will do most harm.

5. When the rate of compensation can only be increased at the *certain* cost of a corresponding increase in the rate of tangent grades (making very sure that it is certain, and not an over-hasty conclusion from inexperience or lack of care), no larger rate than we feel practically certain will be required to balance the curve resistance (0.03 to 0.04) should be chosen.

Otherwise, we are committing the folly of making a certain addition to the grade in one place, to avoid one in another place which is merely problematical.

6. On any minor gradients where the curvature is not sufficient to bring the virtual profile up to the maximum it is not important to compensate for curvature at all, although it is generally as well to do so, especially at points where to do so will slightly reduce the cost of construction, as is very apt to be the case on long curves.

When not compensated, the curvature merely has an equivalent effect to a slight undulation of gradient which produces no shock to the train and so is not a measurable disadvantage.

7. It is not in the least essential or important to precisely adapt the compensation to the exact length of each curve. The reduced rate may as well as not begin and end at the nearest even station, and may be made a little less on one curve and a little more on one immediately above if a horizontal slice of a foot or more may thereby be taken off a high fill on the tangent connecting them, but never so as to cause the grade to rise above the uniform grade-line.

8. Curves immediately below a known stopping-place for all trains need not and should not be compensated at all.

9. The rate of compensation should be uniform per degree for all degrees of curvature, or in no case made greater for the sharper curves. It may even be made less for curves of over 10°. If the rate be reduced one-half for the excess over 10°, making the compensation for a 16° curve thirteen times that for a 1° curve, it will certainly lead to no bad results, although a rather rough rule.

This is directly contrary to the usual practice, which is to increase the rate of compensation with the sharpness of the curve, if anything; but this practice rests upon the assumption which we have seen to be the direct contrary of the truth, that the curve resistance increases with the degree of the curve. The results of experience on the New York elevated lines and numerous others with very sharp curves, both of standard and narrow gage, is enough to disprove this, confirmed as it is very directly by the indications of theory.

10. Since we have seen in Chap. VIII. that there is no reason to believe that curve resistance increases per ton with the length of the train, or even (appreciably) with the type of engine there is no reason for varying the compensation because of the grades or length of train, except for this—that it is usually easier to spare the elevation for a liberal rate of compensation with low grades than with high ones. It is, therefore, proper to do so.

Notes and Queries.

An error in titles to cuts occurred in the making up of our last issue. The article, "The Utilization of Peat as Fuel" was accompanied by three figures, of which the second showed a coking retort and the third showed a gas producer. The captions to these two cuts were interchanged; the producer was called "Fig. 2. Coking Retort, etc.," while the retort was called "Fig. 3. Producer, etc." Careful readers will probably have noted the error, but we mention it here so that it may be corrected in filed copies.

S. & H., Portland, Ore., writes that a sewer was recently constructed at a certain contract price per lineal foot and in a horizontal distance of 1,260 ft. there was a rise of 108 ft. The contractors claim that they are entitled to payment for the actual length of sewer built, measured on the slope. The engineer claims that they are entitled to pay only for the horizontal distance covered. The inquiry is made as to what current practice is in making such measurements, and what the courts have ruled in such cases.

The contractors would certainly appear to be entitled to payment for the length of sewer actually built, yet a contrary practice may have grown up, due to the payment for such work by assessment on abutting property-holders whose frontage measurements were of course based on the horizontal. We doubt whether the point has ever been before the courts, for in the great majority of cases the difference is too trifling to be worth fighting over. In the present case, for example, the sewer is only a little over 4 ft. longer than its horizontal projection, or a difference of less than one-third of 1% in the two methods of measuring the work.

GERMAN ELECTRIC RAILWAYS, says a report dated Oct. 1, 1901, have an aggregate length of 1,940 miles, or 2,844 miles of single track. They serve 113 separate towns and cities.

HOT WATER VS. STEAM HEATING FROM CENTRAL POWER STATIONS.*

By D. F. McGee.†

Before we compare the merits of the two systems of central station heating, namely, exhaust steam and hot water, it would perhaps be well to devote a few moments to a few facts which we have found to be necessary to the financial success of a heating plant: (1) The investment must be kept as low as consistent with good workmanship and first-class construction; (2) the proposition should be to utilize only the exhaust steam to the best advantage by installing only just sufficient mains and radiation to use up all the exhaust steam during time of maximum load. My experience with the various steam, hot air and hot water systems has convinced me that nothing meets the universal requirements for a central plant as well as hot water. In fact, it is the only heating system in which regulation of temperature in the various buildings is absolutely under the control of the attendant at the central plant without a complicated system of thermostats which increase the first cost of installation, and are always getting out of order, and are consequently a continuous source of expense. In our plant we have posted near the thermometer in the main supply pipe a tabulated schedule by which the engineer can tell at a glance how hot the water must be to warm the buildings to 70° at any given outside temperature. As a result, our customers seldom touch a radiator valve during the entire season.

The fact that a hot water heating plant can be operated in connection with condensing engines is a great advantage. The exhaust heater can be placed between the engines and condenser. With 26 ins. of vacuum you can get about 115° on the circulating water, which will answer on chilly days. With 22 ins. vacuum you can get about 140°; with 19 ins., 153°; with 15 ins. vacuum, about 168°. Our records for the past winter show that for 85% of the heating season our circulating water was below 165°. When you need hotter water and the vacuum drops to 15 ins., it pays to throw open the relief valve and run your engines non-condensing. This kind of scheme makes the most economical kind of an arrangement, as a large portion of the winter consists of mild weather.

Our Red Oak plant was started up in October in 1899, and the first season we had about 14,000 sq. ft. of radiation in service. This gave us a loss of 8° from the time the water left the plant until it returned, when the thermometer was — 10° F. Last year we increased our load to 29,000 sq. ft., and the difference during our coldest weather was 15°, with a difference of 20 lbs. pressure between the supply and return mains at the plant. This year, with about 35,000 ft. of radiation in service, we have a difference of from 20 to 30 lbs. between the supply and return mains. We found that it required just 20 HP. to maintain this pressure, with a drop of 15°.

Our pipe system consists of a closed loop or circuit of 5-in. pipe about ¾ mile long, with three 3-in. shunts, each about 1,000 ft., extending off the main line. In this circuit, and forming part of it, is a centrifugal pump, an exhaust steam heater and a live steam or auxiliary heater. The exhaust steam from our engines first passes through an open feed water heater and grease extractor. It then passes through the exhaust heater for the heating system, the surplus, if any, escaping to the atmosphere.

As this exhaust heater is elevated above the water line in the open feed water heater, the condensation from the exhaust steam flows to the feed water heater by gravity, to be pumped to boilers as feed water. This insures us distilled water for our boilers at a temperature of at least 205°, and enables us to use our water over and over again, which makes a very material reduction in our water bill as compared with the ones we pay in the summer months. There is an opening direct to the atmosphere from the exhaust heater at all times, so it is impossible to put any back pressure on our engines, and indicator cards taken from engines show that we can condense every particle of our exhaust steam without using an ounce of back pressure.

The live steam heater is elevated some distance above the boiler, and is similar to the exhaust heater, only much smaller. Here also steam passes through tubes surrounded by the circulating water of the system. When live steam is required for heating, it is taken from the main steam pipe direct to this heater. The condensation from the live steam returns to the boilers by gravity at the temperature corresponding to the pressure. This means returning the water to the boiler at a temperature of over 300°, instead of allowing it to flow to the sewer, which is done in all steam plants.

Our house connections are merely shunts taken off the mains. The size of each house shunt depends upon the number of feet of radiation required in the house to be warmed.

All underground work must be done in the best possible manner, bearing in mind that the mains cannot be covered too thoroughly with a non-conductive material. All pipes should be thoroughly tested and leaks repaired while they are yet uncovered, for every drop of water, in fact,

*Abstract of a "joint" paper presented at the annual convention of the National Electric Light Association at Cincinnati, May 20, 22.

†Red Oak, Ia.

every heat unit, represents money invested, and should be guarded accordingly. It pays to cover all cellar piping, such as mains and branches, with a non-conducting material at your own expense. I find that 1-32-in. asbestos paper, which comes in rolls of about 100 lbs., answers this purpose very well. We saw the roll up into blocks about 6 ins. in length. This gives us long strips of paper 6 ins. wide, which should be wound spirally around the pipe, first in one direction and next the reverse, until there are several thicknesses around the pipe. This is much cheaper than and very nearly as effectual as sectional covering.

While we cannot state accurately the amount of coal chargeable to heating service during the past season, yet we are able to estimate the same very closely from our past records, and find that it is about 600 tons, which costs $1.70 per ton, or $1,020. We have in actual service this season 35,000 sq. ft. of radiation. This brings us an income of $5,250.

When we installed our heating plant we placed wooden boxes to cover junction valves and house connections. On account of the city of Red Oak paving its streets this year, we decided to replace the wood boxes with brick ones, and we uncovered practically all of our mains (wrought iron), which we found to be in excellent condition.

By J. F. Porter.*

Our heating plant was constructed and placed in operation in October and November, 1899.

We now supply about 50,000 ft. of radiation, placed in residences, business houses, offices and schools, and where the amount of radiation installed is sufficient to counteract the exposure the system is giving most excellent satisfaction. Ae we have used no live steam, and the repairs for two years have amounted to less than $400, we consider that our investment is very fair and will be more desirable as time passes.

During the first two years we operated our plant without any back pressure on our engines; but owing to the increase in the number of feet of radiation and the severity of the past winter, we found it necessary to weight our back-pressure valve until the gage showed 3 to 5 lbs. during the period when there was but little electric light and power load, but during the late afternoon and until midnight we found that we had ample steam to furnish heat without back pressure on the engines. We originally installed a hot water system, instead of an exhaust steam, because of the fact that no back pressure was required, and by returning the water to the power plant we retained all the heat units not actually thrown off for the purpose of earning revenue.

We find that if we send the water out at 200° we have, at a distance of 2,000 ft. from the power house, a temperature of 198° where the water leaves the main line to enter the service of the customer. We also find that when the water is sent out at 200° and passes through the radiators and returns to the power house, our loss varies from 30° to 50° F., depending upon the outside temperature.

We have experienced very little trouble from leakage on our pipe system, our only loss to mains and service pipes being caused by surface water passing through the sandy covering and corroding the pipe on its exterior.

By P. H. Korst.†

In making our investigations as to the best system of central station heating to install, we were influenced by the following points in favor of hot water: Utilizing exhaust steam without putting back pressure on the engines; even being able to run engines condensing, passing the exhaust steam through a circulating water heater on its way to the condenser. We have not tried this yet, but are guaranteed to be able to maintain a temperature of 160° in the circulating water and have a vacuum of 18 ins. on the engines. Doing away with back pressure and the ability to run engines condensing mean a large saving in fuel.

With exhaust steam heat a temperature of 212° or more is obtained whenever there is steam on, and for fully three-fourths of the heating season this is much more than is needed. Much heat and pure water is lost when the condensation is wasted in the sewers. With hot water, the temperature of the water can be varied to suit the outside temperature, and thereby give the customer an even heat. The condensed exhaust steam in the heater can be returned to the boilers after trapping out the oil, if the engines are running non-condensing. Absence of noise, water hammer, odor and air in radiators are also good features.

The large amount of water in the pipes and radiators makes a certain amount of storage capacity for heat, and a system may be stopped in emergencies with a very gradual cooling of the water. Fuel economizers can be used to impart some heat to the water, and live steam heaters are generally used to add extra heat in very severe weather and also at times when not enough exhaust steam can be obtained. In a hot water system with a forced circulation, no attention need be given to the grade of the flow or return pipes, which simplifies and cheapens the installation. If a closed system is used—that is, one not open to the atmosphere at any point—the circulating pumps take only enough power to overcome the difference in pressure between the water in the flow and return pipes, or just enough to overcome the friction of the water in the pipes. In an open system, in addition to this, enough pressure must be used to raise the water to the highest point on the system.

Proper insulation of mains and service pipes is a simpler proposition with hot water than with steam, on account of the lower temperature, which permits the use of efficient material that would deteriorate under the higher temperature of steam heating.

By C. R. Munsell.*

We now have invested about one-sixth of our total investment in the steam heating system.

Taking into consideration the cost of coal, inspection and all other expenses outside of station for a period of five years, the cost of operation has been 37% of the gross revenue. These expenses do not take into consideration extra wear and tear on boilers, nor any increased labor in the station.

The enginemen regulate the pressure by a schedule which was compiled in accordance with the outdoor temperatures, this being the varying factor. The average temperature for this locality during the months from October to May, inclusive (which is our heating season), as taken by the Government Weather Bureau from 20 years' records, shows 43.9°.

The maximum back pressure is required but a few hours during the heating season of 5,760 hours, or eight months. Therefore it need only be considered from the standpoint of the capacity of the engines, if the revenue will pay for all coal used and also interest on the investment. To illustrate this point, for only 60 hours last season was it necessary to carry the maximum, 6 lbs. pressure.

Our system consists of 12,763 sq. ft. of radiation in mains, 1,640 sq. ft. of radiation in service pipes, 8,640 sq. ft. of radiation in covered piping in buildings not charged for, and 67,239 sq. ft. of radiation charged for. This radiating surface heats 6,528,475 cu. ft. The amount of steam condensed per sq. ft. of radiation during the heating season, as measured by the water meter, we have found to be 360 lbs.; this equals at meter rate of 60 cts. per 1,000 lbs. of water, about 22 cts. per sq. ft. of radiation. The greatest distance from the power house to which steam is supplied is 2,800 ft.

The service connection from the steam mains to the house piping is paid for by the consumer, and all the inside piping, radiators and necessary appliances are owned and maintained by the consumer, with the exception of meters, which are the property of the Edison Co.

Steam is supplied by flat rate (yearly contract), or by meter system on the following conditions: If the building to be heated contains a store room on the first floor and offices or living rooms on the upper floors, the company will contract with the tenant of the store direct, but will in no case furnish steam to the tenants of upper floors unless the owner of the building will sign a contract for the heating service.

If steam is wasted by consumers not turning off radiators in moderate weather, the company reserves the right to charge by meter.

Buildings to be heated from our street mains must have sufficient radiating surface so that they can be heated to a temperature of 72° in zero weather with a steam pressure of 2 lbs., and in no case will an installation for heating be accepted unless there is 1 sq. ft. of heating surface for each 100 cu. ft. of air space. The number of feet of radiation required depends entirely on the exposures and construction of the buildings, and 1 ft. of radiation is sometimes required to each 50 cu. ft. of air space.

The water of condensation must all be carried to a cooling coil, this coil to contain at least as many feet of surface as one-fifth of the radiating surface contained in the total installation of the building. After the water has been through the cooling coil it must be carried to the sewer.

The one-pipe loop system of installation gives the best results, and should be used on all new work. The rates are as follows:

30 cts. per sq. ft. for direct radiation per season.
35 " " " " " indirect " " "
20 " " " " " cooling coil " " "
Meter rate, 60 cts. per 1,000 lbs. of water.

A square foot of radiation is about 3 ft. of 1 in. steam pipe, and a charge is made for all piping which is not covered with an approved non-conducting covering, whether contained in radiators, coils or piping to radiators.

*Alton, Ill.
†Janesville, Wis.

CAR LIGHTING by the Pintsch compressed oil gas system is rapidly superseding all other methods of illuminating railway cars in the United States. Figures furnished us by the Safety Car Heating & Lighting Co., corrected to May, 1902, show 18,497 passenger cars in the United States equipped with its apparatus, and 63 gas manufacturing plants in operation. As the total number of cars in passenger service in the United States is about 35,000 it will be seen that over half this rolling stock is now equipped with gas lighting apparatus. Figures are also furnished showing that up to May, 1902, the railways of the world had 112,191 cars and 5,000 locomotives equipped with Pintsch gas apparatus, and it was also in use on 1,211 buoys and beacons.

*Topeka, Kan.

A CLASSIFIED REVIEW OF DAM AND RES[ER]VOIR FAILURES IN THE UNITED STATES.*

By William R. Hill,† M. Am. Soc. C.

In this address it is my purpose to call your a[t]tention to faulty construction of dams and reservoirs re[s]ulting in the destruction of life and property. The most [fre]quent cause of such casualties will be found to be due [to] insufficient spillways thus causing the water to rise in [the] reservoirs and to flow over and wash away the embank[ment].

INSUFFICIENT SPILLWAYS AND OVERTO[PPING].

MIDDLEFIELD, MASS.—Failed on April 21, 190[1]. Earth, faced with rubble walls and with two lines of sh[eet] piling driven 15 ft. apart with the space between th[em] filled with puddle. Dam 500 ft. long, 20 ft. high, 50 ft. [thick] at base, 30 ft. at top. Failure caused by water flow[ing] over the crest. Four highways bridges were carried [away].

VICTOR, COLO.—Dam failed May 19, 1901. E[arth] 430 ft. long, 25 ft. high. The reservoir held 70,000,000 [gal]lons of water, all of which escaped; inadequate spillway.

LEBANON, O.—Reservoir having an area of [40] acres failed July 10, 1882. The embankment, which was [50] ft. high, was destroyed by water flowing over its cre[st]. Five bridges and many houses valued at about $50,000 were swept away.

LIMA, MONT.—A large storage reservoir near Lima, Mont., was suddenly emptied by the washing out of the spillway in May, 1894, the dam being left intact. The lower end of the spillway had a fall of 30 to 40 ft. and a flood rapidly cut a huge channel back from the fall into the reservoir. The reservoir was said to have been 15 miles long and a mile wide.

AVOCA, PA.—A dam of a 350,000-gallon reservoir near Avoca, Pa., failed on May 25, 1894; insufficient spillway.

OIL CITY, PA.—The Spartansburg dam, near Oil City, Pa., failed June 4, 1892. It was 180 ft. long and 10 ft. high, and impounded a lake 1½ miles long and 1 mile wide. The dam was of earth and rock, with center sheet piling for 150 ft. only. The 30 ft. without piling was carried away. There was no waste weir other than a small flume, and the failure was caused by water running over the crest of the dam.

FISHKILL, N. Y.—Melzingah reservoirs Nos. 1 and 2 failed on July 14, 1897. Each reservoir had a capacity of 6,000,000 gallons, and was formed by a dam of earth with masonry core wall. The upper dam, which was 250 ft. long and 30 ft. high, failed first. The lower dam was 220 ft. long and 24 ft. high. Seven lives were lost and $30,000 worth of property was destroyed. The cause of failure was a freshet flowing over the crest of both dams.

GRAND RAPIDS, MICH.—The city reservoir failed July 2, 1900. The embankment was of earth with clay puddle core, lined on the inside with rubble masonry in cement, 1 ft. thick, resting on a layer of concrete 1 ft. thick. The bank was 12 ft. wide on top, the inner slope was 1½ to 1, and the outer slope was 2 to 1. The capacity of the reservoir was 6,000,000 gallons, with water 25 ft. deep. The failure was caused by water flowing over the top of the bank, and the damage due to it amounted to about $100,000.

WALNUT GROVE DAM.—On the Hassayampa River, 30 miles south of Prescott, Ariz.; failed on Feb. 22, 1890. It was 110 ft. high from the rock foundation to the coping, 400 ft. long, 140 ft. thick at the base and 10 ft. at the top. It was a rock-fill dam with walls on both faces made of large granite blocks of dry masonry, with a timber lining on the water side. The walls were 20 ft. thick at the bottom and 5 ft. at the top. The waste weir was only 26 ft. wide, while the area of the watershed was about 500 sq. miles. The reservoir had an area of about 1,000 acres. The cause of the failure was supposed to be water flowing over the crest of the dam. About 150 lives were lost and the damage to the dam and the property destroyed was estimated to be about $800,000.

JOHNSTOWN, PA.—The dam was constructed in 1852 for a reservoir feeder for the Pennsylvania Canal. In 1857 it was abandoned and in July, 1862, a culvert in the embankment gave way owing to some imperfection of the foundation. The depth of water at that time was about 40 ft., all of which was discharged with the exception of about 8 ft., but owing to the substantial character of the dam the leakage was slow and but little damage was done. From 1862 to 1880 the reservoir was empty, and in the latter year the dam was reconstructed to a height 2 to 3 ft. lower than originally. A fatal mistake was made in leaving a low place or sag in the middle of the dam. Another mistake made was the obstruction of the spillway with an iron grating placed to retain the fish in the reservoir. On May 31, 1889, the water rose, flowed over the crest of the dam because the spillway was too small to

*Abstract of the address of the President of the American Water-Works Association, at the annual convention of the association at Chicago, June 10, 1902. The paragraphs relating to the several failures have been slightly rearranged and condensed. Reference to the "General Index to Engineering News," 1890 to 1899, and to our half-yearly indexes of later date will enable readers to find more extended descriptions of many of these failures.—Ed.

†Chief Engineer, Croton Aqueduct Commission, New York City.

discharge the water, and in a short time 400 ft. of the dam washed away. The loss of life was variously estimated at from 4,000 to 10,000, and the damage to property amounted to about $9,000,000. The reservoir had an area of about 400 acres, an average depth of 30 ft., and a capacity of about 5,000,000,000 gallons. The area of the watershed was about 60 sq. miles. The dam was constructed entirely of clayey earth, 72 ft. high, 20 ft. wide on the top with an inside slope of 2 to 1, and an outside slope of 1½ to 1. The inside slope was protected with a layer of riprap.

FAILURES DUE TO WATER LEAKING ALONG PIPES LAID THROUGH EMBANKMENTS.*

FAIRTOWN, WYO.—The dam of Rock Spring waterworks reservoir, above this place, burst Feb. 2, 1888.

WILMINGTON, DEL.—A reservoir bank failed in October, 1900. It was of earth lined with clay and faced with brick. It was 10 ft. high where the break started. The failure was supposed to be due to leakage along pipes.

EAST LIVERPOOL, O.—A reservoir failed Oct. 13, 1901, when it was being filled for the first time. It was lined with 18 ins. of concrete laid on 27 ins. of puddle clay. It had a capacity of 12,000,000 gallons. The break occurred over a pipe laid through the embankment.

ANSONIA, CONN.—The embankment of a reservoir broke Nov. 3, 1894, making a gap 200 ft. long and 35 ft. deep and washing out about 200 ft. of the roadbed of the New York, New Haven & Hartford R. R.

GUNNISON, CAL.—A dam burst on May 21, 1890. The reservoir was 5 miles long, about 1½ miles wide and 20 ft. deep.

STAFFORDVILLE, CONN.—An earth embankment with a masonry face wall gave way on March 27, 1877. The embankment was 26 ft. high and 150 ft. long and the wall was 10 ft. thick at the base and 4 ft. at the top. Some lives were lost and the damage to buildings, bridges, etc., amounted to about $300,000.

LANCASTER, PA.—A reservoir failed on Oct. 14, 1894, while first being filled. The embankment was of earth with puddle center. The reservoir had a capacity of 15,000,000 gallons with the water 21 ft. deep. The water was seen to gush out from the outer slope of the embankment and in an instant a break 30 ft. in width was made, through which the reservoir rapidly emptied. The reservoir was lined with clay, protected by a coating of cement mortar, then a brick paving finished with grout.

PORTLAND, ME.—The embankment of a 20,000,000-gallon distributing reservoir failed on Aug. 6, 1893, after having been in use four years. The embankment was without a core wall and was 10 ft. wide on the top, 45 ft. high, and the slopes were 1½ to 1 on each side. Six feet of the inner slope was puddled clay and 6 ins. of broken stone, upon which was laid granite paving blocks 8 ins. thick. A drain pipe was laid through the natural surface under the embankment, and an overflow pipe was laid over it sloping downward through the embankment. The break occurred over these pipes. The cause of the failure was said to be either the action of frost, or the light embankment, or water following the pipes. Much damage was done and four lives were lost.

FISKVILLE, R. I.—The dam of the Spring Lake reservoir near this place failed Aug. 25, 1889. The reservoir had a capacity of 35,000,000 gallons. The dam was made of clay and gravel and was 825 ft. long, 18 ft. high, 8 ft. wide on the top and 35 ft. wide on the bottom. The outside slope was retained by a stone wall and the inner slope was paved with stone. The portion washed away was just above the waste pipe. Property valued at about $25,000 was destroyed and three lives were lost.

WORCESTER, MASS.—The Lynde Brook reservoir embankment failed on March 29, 1876. It was of earth, paved on the inside with rubble masonry, on a slope of 2 on 1. It was 287 ft. long, 27 ft. high and 25 ft. wide on top. The embankment was originally built in 1854, was enlarged and modified in 1870 when it was made 19 ft. higher, and a heavy face wall of masonry was added. The reservoir had a capacity of 776,000,000 gallons. Water leaked around a culvert that passed through the base of the embankment, making a breach 200 ft. long and destroying property valued at nearly $1,000,000.

FAILURES OF RESERVOIR BOTTOMS.

ROANOKE, VA.—City reservoir caved in on Nov. 10, 1888, causing a loss of about $15,000.

KNOXVILLE, TENN.—The puddle bottom of a double reservoir failed on May 31, 1883.

CONSHOHOCKEN HILL, NEAR PHILADELPHIA, PA.—A reservoir with a capacity of about 1,000,000 gallons was lined with about 18 ins. of clay, upon which was laid a brick paving in cement. The bottom lining broke away in 1873 and was repaired. It failed again in the years 1876, 1879, and 1886.

PORTLAND, ORE.—The concrete lining of a reservoir cracked badly before water was let in. The concrete was 5 to 6 ins. in thickness with ⅝-in. square twisted rods bedded in the concrete every 2 ft. in each direction. On Dec. 13, 1894, water was turned into the reservoir and serious leaks and further cracks appeared in the bottom lining.

BROOKLYN, N. Y.—The Milburn storage reservoir was completed in 1893 and has never been in use. In August of that year 43,500,000 gallons of water were pumped into it, all of which leaked out through the bottom in a period of ten days. The puddle bottom of the reservoir was considered to have been improperly put in, although it was generally of good material. Experts have recommended that the entire bottom of 44 acres be repuddled, though nothing has yet been done in regard to their recommendations.

PHILADELPHIA, PA.—A leak in one of the basins of the Roxborough reservoir was discovered in 1894, after the reservoir had been in use nearly a year. A depression was found in the embankment about 3 ft. above the bottom. Underneath the brick lining the clay had been washed away, and below there was a fissure in the rock 6 to 10 ins. in width. Through this fissure the water escaped, coming to the surface 1,200 ft. away. Water was first pumped into this reservoir on Sept. 21, 1893. When it had been filled to a depth of 20 ft. an increased flow was detected in a spring nearby. The leak was not located for nearly a year after. An expenditure of about $140,000 was required to reconstruct the interior lining.

The Queen Lane reservoir, of Philadelphia, was practically completed on Oct. 1, 1894. Later it was filled to a depth of 10 ft. and developed leaks at many points. The bottom was lined with 4 ins. of concrete and was upon a layer of clay puddle 2 ft. in thickness, which was built up in layers, rolled and watered. The rock underlying is gneiss and mica, and the upper portion of this is more or less disintegrated. The cost of reconstructing the interior lining of the reservoir was about $275,000.

EMBANKMENTS AND WALLS UNDERMINED WHERE BUILT UPON POROUS OR YIELDING MATERIAL.

TACOMA, WASH.—The dam of the Light & Power Co. was undermined in December, 1892. It was built of timber and was about 120 ft. long, holding back a depth of 17 ft. of water.

HOUSATONIC DAM, NEAR BIRMINGHAM, CONN.—Failed in the latter part of January, 1891. It is a curved masonry dam, 636 ft. long, 40 ft. high, 25 ft. thick at base and 8 ft. at coping, costing $264,000. In 1869, while under construction, a heavy freshet carried away 160 ft. of the partly-finished work and scoured out a cavity 20 ft. deep in the river bed. This cavity was filled with loose rock and a timber apron, filled with concrete, was placed upon it. Twenty-two years afterwards 250 ft. of the dam was swept away by the undermining of the loose rock under the timber apron.

DALLAS, TEX.—A break in the reservoir embankment occurred in June, 1891. The embankment was of clay without a core wall, the inner slope paved with brick in cement, set on edge upon 3 ins. of gravel. It was 29 ft. high and 12 ft. wide on top, with an inner slope of 2 on 1. The reservoir had a capacity of 140,000,000 gallons. A large part of the bank sank vertically, due as was thought to quicksand beneath the foundation. The settlement was over 300 ft. in length and extended from the toe of the outer slope to within 5 ft. of the top of the inner slope. The brick and cement lining was cracked in an almost straight line at 11 ft. from the top, and from this line to the top of the embankment there was a slight settlement.

CALAVERAS COUNTY, CAL.—The Angel's Dam was undermined on April 10, 1895. This dam, costing $52,000, was of rubble-stone masonry, 400 ft. long and 52 ft. high. It was 35 ft. thick at the base, and at a height of 20 ft. the thickness was abruptly reduced from 21 to 13 ft. At the top it was 3 ft. thick. The upstream face of the dam was vertical. During the time of construction workmen were engaged digging a hole near the wall, and the foreman said "they were trying to dig out a cottonwood stump, but the blamed roots ran clear under the wall and he could not get them out." One life was lost by the flood.

WILLIAMSBURGH, MASS.—The Mill River Reservoir Dam burst on May 16, 1874. The dam was of earth with a masonry core wall. It was 600 ft. long, 43 ft. high and 16 ft. wide on top with slopes of 1½ to 1 on both sides. The core wall was 2 ft. thick at top and 5 ft. 9 ins. at bottom. It was laid in a trench on an earth foundation 3 ft. below the natural surface. The reservoir had an area of 114 acres and an average depth of 20 ft. Water found its way under the core wall and destroyed the embankment. The reservoir was suddenly emptied into a narrow valley, causing the loss of 140 lives and the destruction of about $1,000,000 worth of property.

POOR WORKMANSHIP OR FAULTY DESIGNS.

LITTLE ROCK, ARK.—The dividing wall of a reservoir burst on Nov. 2, 1887. The wall was of rubble masonry 36 ft. high, 12½ ft. thick at bottom and 7 ft. at top. The reservoir held 7,000,000 gallons of water in each basin.

MUD POND DAM, NEAR EAST LEE, MASS.—Failed April 20, 1886. This dam was of earth with a dry boulder wall on the downstream side. It was 325 ft. long, 15 ft. high, 28 ft. thick at base and 6 ft. at top, and is said to have been poorly constructed. Seven lives were lost and the damage to property amounted to about $250,000.

OAKLAND, CAL.—To increase the capacity of a reservoir about 100 ft. square on Vernon Heights, a wall of asphalt concrete was built around it. The wall was 8 ft. high and only 2 ft. thick at the base and 1 ft. at the top. It had no depth in the soil and was built partly on made ground. It failed Oct. 20, 1896.

SCRANTON, PA.—A reservoir gave way on Oct. 10, 1895. The walls were of rubble with dressed granite faces, filled with concrete and strengthened with stone buttresses, about 24 ft. apart. The wall was 10 ft. thick at base and the depth of the water was 20 ft. About 120 ft. of the wall gave way after having been in use ten years.

NEBRASKA CITY, NEB.—Two new reservoirs failed on April 10, 1890, shortly after being put into use. The banks were of earth, 8 ft. wide on top, with slopes of 1 on 1 inside and 1½ on 1 outside. The depth of water was 17 ft. The soil was very porous and to prevent the percolation of water the embankments and bottom of the reservoir were lined with 2-in. plank which was covered with about a foot of earth.

NORTHFIELD, VT.—A timber dam failed Aug. 27, 1890. It was 100 ft. long and 25 ft. high at the deepest point. It was built of single layers of 12 × 12-in. hemlock timbers, 10 ft. long, simply placed one above the other and drift bolted together. The dam was roughly in the form of an arch of 40 ft. radius, and each set of timbers formed a 10-ft. chord of the arch. They were not fastened together at the ends by spiking or by any vertical binding pieces. The only additional part to the dam, besides the 12-in. timbers, was an interior vertical lining of 3-in. planks, making the dam only 15 ins. thick. In placing the planks the end joints were not broken. The dam stood the test of being filled twice within a period of 8 days before it failed. No engineer was in charge of the construction.

ICE PRESSURE.

CLEVELAND, O.—The Kinsman St. Reservoir failed in December, 1886, because of ice pressure and the sudden drawing off of the water..

DES MOINES, IA.—A concrete dam of the Water Power Co. failed in March, 1893, due to ice, undermining and faulty construction.

MONTREAL, P. Q.—In 1896 a 42,000,000-gallon reservoir leaked at the rate of 350,000 gallons per day. The leakage is believed to have been caused by the ice near the high-water line. The reservoir was formed by a masonry wall, backed first with puddle and then with an earth and stone embankment.

MINNEAPOLIS, MINN.—The upper dam of the St. Anthony's Falls Water Power Co. failed on April 30, 1899. It was of coursed ashlar sandstone masonry, 530 ft. long, 18 ft. high, 12 ft. thick at base and 5 ft. 1½ ins. at top. The damage amounted to about $25,000 and was attributed to ice pressure.

MISCELLANEOUS OR UNKNOWN CAUSES OF FAILURE.

MAHANOY CITY, PA.—Dam No. 2 of the Water Co. gave way June 17, 1892. It was of puddled clay without a core wall. The inner slope was paved and the outer slope covered with large stone. It was 130 ft. thick at bottom and 25 ft. at top. The depth of water was 18 ft. and the capacity of the reservoir 3,000,000 gallons. The dam had been under repair. Much damage was done and one life was lost.

BAKER CITY, ORE.—The bursting of a dam of a reservoir at the head of Goodrich Creek, 12 miles from this place, on June 15, 1896, caused extensive damage in the valley below. One farm house was carried away and an entire family of seven persons was drowned.

STAUNTON, VA.—The bursting of the dam of the lake at the fair grounds Sept. 30, 1896, due to high water, caused a flood which did considerable damage to property and in which five lives were lost.

JEFFERSON COUNTY, COLO.—A small dam near Ward burst July 9, 1897. Two lives were lost and $50,000 worth of property was destroyed.

ANSONIA, CONN.—Two of the reservoir dams on Beaver Brook, near this place, were carried away on March 26, 1884, liberating about 50,000,000 gallons of water. One railroad and two highway bridges were destroyed and the total damage amounted to about $250,000.

EDDY, N. M.—A rock-fill dam across Pecos River, six miles above this place, failed on Aug. 6, 1893. It was 1,040 ft. long, 45 ft. high, 21½ ft. wide at water level and 6½ ft. at top. On the upstream slope the rock was laid 1½ on 1, faced with earth with a slope of 2 on 1, and the downstream slope was 1 on 1.

ELLINGTON, CONN.—On Sept. 18, 1890, a dam near the head of Broad Brook in the town gave way and the flood swept down the valley, carrying away five dams, two railway trestles, six highway bridges and other property, making an aggregate loss of about $50,000.

AUSTIN, TEX.—A masonry dam on the Colorado River, costing $1,400,000, failed on April 7, 1900. It was 1,275 ft. long, 68 ft. high and 66 ft. thick at base. A freshet and great depth of water flowing over the crest forced 500 ft. of the dam down the river. The damage to property amounted to about $500,000.

In addition to the cases cited above, 48 other failures of dams and reservoirs in this country have come to my notice. It is very unfortunate that the records relating to them do not contain any description of the structures, the purpose of their construction or the cause of the failures. It is my hope that all who become acquainted with failures of dams or reservoirs will impart such knowledge to this association, as well as to the engineering journals whose columns contain many object lessons for our guidance and education.

*Unless otherwise specified, the causes of the next nine failures are as indicated by this heading.—Ed.

50-TON STEEL COAL CAR (VANDERBILT TYPE); WEST VIRGINIA CENTRAL & PITTSBURG RY.

Among the latest of the various designs of steel freight cars now in use are those patented by Mr. Cornelius Vanderbilt, Jr. (who is now engaged in the motive power department of the New York Central R. R.), and we are indebted to Mr. Vanderbilt for plans of his hopper-bottom coal cars, 800 of which are now being built for the West Virginia Central & Pittsburg Ry. by the Cambria Iron & Steel Co., of Johnstown, Pa. Mr. I. N. Kalbaugh is Superintendent of Motive Power of the railway. These cars are of 100,000 lbs. rated capacity (maximum capacity, 120,000 lbs.), and their weight, empty, is 36,500 lbs. The cubic capacity is 1,597 cu. ft. level full, or about 1,892 cu. ft. with the load heaped up at 30° above the sides, which latter would be equivalent to about 104,060 lbs. of coal (at 55 lbs. per cu. ft.). A comparison of these cars with some others of the same capacity is shown in the accompanying table.

The general design and construction of the Vanderbilt steel cars are shown in Fig. 1. They are built of plates and structural shapes, and the underframe consists essentially of the center sills and end sills, no side sills being required, as the sides are practically plate girders. The center sills are 15-in. channels, set back to back, 15 ins. apart, with spacing pieces of similar channels. The end sills are 5-16-in. flanged plates, 8 ft. 9 ins. long; the horizontal leg is 9 ins. wide throughout, while the vertical leg is 6 ins. deep at the ends and 15 ins. at the middle, reinforced by an inside angle iron on the lower edge. The end sills are braced by 6-in. channels from the ends of the bolsters, and by diagonals from the bolster plates. These diagonals are 6-in. channels, laid flat. The body bolsters consist each of a pair of ⅜-in. plates riveted to the sills and to 6-in. channels extending from the end of the bolster to the end of the end sill. Above the bolster is a pair of 10-in. channels, set back to back, resting on top of the center sills and secured to them by vertical plates which are riveted to the backs of the bolster channels and to vertical angle irons on the sill channels. Riveted between the bolster channels, at each end, is a 6-in. vertical channel forming one of the supports of the side. The draft rigging is fitted between the center sills, as shown, and the cars are equipped with Tower M. C. B. couplers and the Sessions friction draft gear. The cars are mounted on diamond frame or arch-bar trucks.

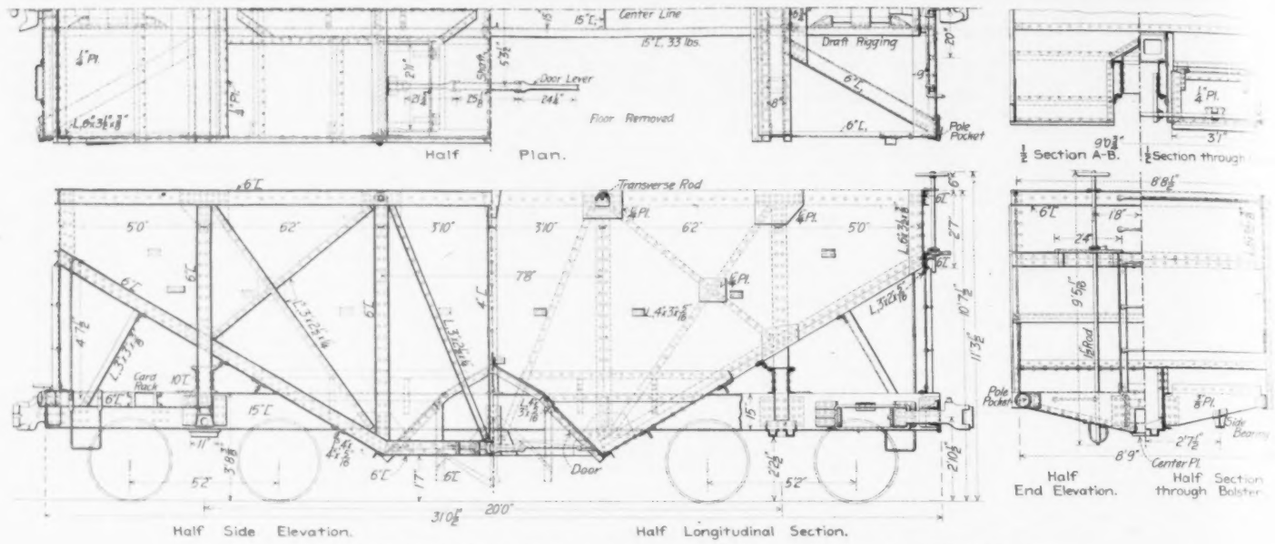


FIG. 1. 50-TON STEEL COAL CAR; WEST VIRGINIA CENTRAL & PITTSBURG RY.
Cornelius Vanderbilt, Jr., New York, Inventor. Cambria Iron & Steel Co., Johnstown, Pa., Builders.

Comparison of Hopper-Bottom Coal Cars of 100,000 lbs. Capacity.

Railway	W.Va. C. & P.	So. Pacific.	Nor. & Westn.	Bess. & L.E.	Pennsylvna.
Material	Steel.	Wood.	Steel & wood.	Steel.	Steel
Length over sills	31 ft. 0½-in.	36 ft. 0 ins.	33 ft. 0½-in.	29 ft. 6 ins.	33 ft. 0 ins.
Length inside	30 " 0⅛-in.	33 " 11 "	30 " 9 ins.	28 " 0¼"	31 " 6⅛"
Width inside	8 " 8½ ins.	8 " 3 "	8 " 9½"	9 " 2 "	9 " 6 "
Height, rail to top	10 " 7½ "	10 " 5¾"	10 " 1 "	8 " 9 "	10 " 6 "
Height, rail to hopper	1 " 7 "	2 " 3 "	2 " 0 "	1 " 0 "	1 " 6 "
Wheelbase, truck	5 " 2 "	5 " 0 "	5 " 6 "	5 " 7 "	5 " 6 "
Wheelbase, total	25 " 2 "	31 " 0 "	27 " 0½"	30 " 11 "	28 " 9 "
Cubic capacity	1,597 cu. ft.	1,682 cu. ft.	.....	.....	1,672 cu. ft.
Weight, empty	36,500 lbs.	32,868 lbs.	37,500 lbs.	34,000 lbs.	39,300 lbs.
Live load	73.26%	75.27%	72.73%	74.63%	71.79%
Dead load	26.74%	24.73%	27.27%	25.37%	28.21%
In Engineering News	Present issue.	July 19, '00.	.....	Jan. 19, '99.	.....

Note.—The W. Va. C. & P. Ry. cars are of structural steel shapes and plates; the N. & W Ry. cars are of structural steel shapes with plank sheathing; the B. & L. E. Ry. and P. R. R. cars are of pressed steel shapes and plates.

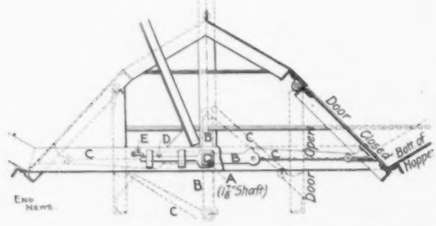


Fig. 2. Hopper Door Mechanism of Vanderbilt Coal Cars.

The bottom of the car slopes uniformly from the ends to the hoppers, a transverse ridge separating the hopper openings and forming the attachment for the doors. The sides, ends and floor are of ¼-in. plate. A 6-in. channel runs along the top of each side, while similar channels are riveted to the lower edges of the side plates. Other 6-in. channels extend vertically from the bolsters and the bottom of the hopper to the top of the car, and the sides are further reinforced by 4-in. vertical channels at the center and by diagonal members consisting of steel angles. The ends are supported by angle iron struts forming the ladder bars, and by ¾-in. tension rods over the sills, while diagonal struts extend from the ends of the end sills. Large ¼-in. connection plates are used at the junctions and intersections of the members. At the top are two transverse angles and 1⅛-in. rods, to prevent the sides from buckling. The side and center bearings are malleable castings, as are many of the other fittings, such as the pole pockets, etc.

The four hopper doors are 37 × 30⅞ ins., built of ¼-in. plate and reinforced by an outside angle iron on all the edges. Each door has two strap hinges with ⅞-in. pins. The doors are operated by levers instead of by chains, the general arrangement being shown in Fig. 3. A transverse shaft A, pivoted in the 6-in. bottom channels at each side, carries at each end a cross-arm B, from the ends of which levers C C extend to the doors, these levers being pivoted both to the door and the cross-arm. When the gates are closed the two cross-arms are horizontal, as are the levers. To open the doors, the shaft is turned, raising the cross-arms into a vertical position, then pulling the doors to a vertical position, as indicated by the dotted lines. When the doors are closed, the shaft is locked by the bar D and latch E.

It is, of course, impossible to nail repair or other cards to steel cars, and some special attachment for the cards is therefore necessary. The Vanderbilt cars are fitted with cast-iron pockets, or racks, Fig. 2, riveted to horizontal channels which run from the bolsters to the end sills. Each pocket has a 1-in. wooden block, 10⅝ × 5¼ ins., to which cards can be nailed in the usual way.

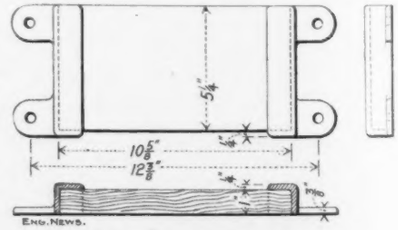


Fig. 3. Card Rack for Vanderbilt Cars.

The principal dimensions of these cars are as follows:

Dimensions of 100,000-lb. Steel Coal Cars;
W. Va. C. & P. Ry.

Length over end sills	31 ft. 0½-in.
" over bottom of hopper	7 " 8 "
" inside	30 " 0⅛-in.
Width over end sills	8 " 9 ins.
Width inside	8 " 8½ "
Height, rail to top of body, light	10 " 7½ "
" " " bottom of hopper, light	1 " 7 "
" " " top of sills, light	3 " 8⅝ "
" " " center of drawbar, light	2 " 10½ "
Depth at hopper	9 " 0½-in.
Depth at ends	2 " 7 "

Hopper doors	2 ft. 5⅝ ins. × 3 ft.
Wheels, diameter	2 ft. 9 ins.
Trucks, wheelbase	5 " 2 "
Trucks, distance center to center	20 " 0 "
Cubic contents, level full	1,597 cu. ft.
Rated capacity	100,000 lbs.
Weight, empty	36,500 "
Weight, loaded	136,500 "
Live load	73.26%
Dead load	26.74%
" " per ton of capacity	730 lbs.
" " per cu. ft. of capacity	23 "

ANNUAL CONVENTION OF THE AMERICAN WATER-WORKS ASSOCIATION.

The 22d annual convention was held at Chicago, June 10 to 13, the headquarters and place of meeting being at the Auditorium Hotel. The meeting was very well attended, about 200 members being present, while the guests and visitors brought the total registration up to about 500. Several good papers were presented, but as a rule the discussions were disappointing, due partly to the indifference on the part of the majority of those present, who were willing to listen but not to speak, and were apparently more interested in the excursions and social features than in the business proceedings. The slighting of the technical discussions was also in part due to the time consumed by the reading of the papers and by various matters of minor importance.

On Tuesday morning, June 10, the meeting was called to order by Mr. H. E. Keller, of the local committee, and the proceedings were opened with prayer by Rev. C. P Stevens. A brief address of welcome was delivered by Mr. L. E. McGann, City Controller, who remarked that compensation for water supply must be reasonable or an investigation is likely to be started that may result detrimentally to the water-works interest; so that extortion has been abandoned (to use Mr. McGann's phrasing), not so much on account of morality as of business policy. He referred to the great waste of water in Chicago, and to the difficulties experienced by that city in getting a good administration of its municipal water-works, and further remarked that he was sorry the association did not include more men interested in the economic side as well as in the technical side of the water supply question. He also alluded to the great importance of water supply in its relations to public welfare, these relations including the distribution, purification, measurement, compensation, etc.

The President, Mr. W. R. Hill, M. Am. Soc. C. E. (of New York), then delivered his address, which consisted of a summary of accidents caused by the failures of dams and reservoirs. We print this nearly in full on another page. The roll of committees was called, but only one committee was heard from, and that had not a report ready.

The President announced the death (on June 9) of Mr. Peter Milne, Assoc. Am. Soc. C. E., who was for several years secretary of the association; and Mr. J. M. Diven, of Elmira, N. Y., was appointed in his place. On motion of Mr. C. H. Campbell, the session then adjourned as a mark of respect to the three deceased members—Mr. Peter Milne, of Brooklyn, N. Y.; Mr. W. H. Laing, of Racine, Wis., and Mr. Wm. Himrod, of Erie, Pa.

OUR ASSOCIATE MEMBERS.

At the afternoon session Mr. C. H. Campbell (Charlotte, N. C.) read a paper on this subject, pointing out the importance of the work done by manufacturers in introducing improved machines and appliances of all kinds. Attention was also called to the work of the editors of the engineering journals in distributing knowledge of new methods and machines and in reporting progress generally.

WHO SHOULD OWN THE WATER METER?

This paper, by Mr. C. W. Wiles (Delaware, O.), outlined the objections to the practice of obliging the water consumer to purchase his meter, and stated the opinions of the author as follows:

The writer is firm in the belief that all water meters should be owned and controlled by the water department or water company and furnished the consumer at an annual rental, covering interest on first cost of the meter and reasonable repairs, according to its size and cost. The consumer should be required to protect it from frost. Then the water department or company has complete control, and when a meter fails to work it is taken out and replaced by another from those in stock. Small repairs, such as replacing a broken wheel, disk, or bolts, can be done at the repair shop. If in need of more general repairs, it can be held and shipped with a dozen or more to the factory by freight, repaired and returned at a much less expense than a single meter.

This paper was received with general approval. Mr. Kimball (Knoxville, Tenn.) stated that his company is obliged by its franchise to sell a meter to any consumer who wants it. The company, however, offers as an alternative to provide its own meter for a payment of 50 cts. per quarter, and this system of rental is accepted by a large majority of the consumers in preference to purchase.

METERS FOR ELEVATOR AND FIRE SERVICES.

The "question box" subjects for discussion were then taken up, and Mr. C. H. Campbell (Charlotte, N. C.) asked whether meters should be put on hydraulic elevator services. The ordinary indicators do not measure the water at all, and has therefore insisted on the use of meters, though consumers have objected on the ground that the indicators acted as meters. Several speakers concurred in this practice, and instances of excessive waste by elevators were cited. In one case the consumption of 80,000 gallons a day was discovered by putting on a meter; this lead to the discovery of a leak, the repair of which reduced the consumption to 5,000 gallons per day.

Mr. G. H. Felix (Reading, Pa.) inquired as to practice in regard to the metering of fire services in buildings, and the discussion followed somewhat indiscriminately on the lines of the two questions. Mr. Campbell remarked that the municipal plant at Charlotte, N. C., makes a charge for sprinkler systems, and has an inspection of these systems in conjunction with that of the insurance inspectors. Mr. F. A. W. Davis (Indianapolis Water Co.) considered that all services should be metered; but the companies having these services will often try to use water surreptitiously, although the charge is very small in view of the great savings that have been effected in cases of fire in buildings having fire service connections. A difficulty, however, arises in some cases from the refusal of insurance companies to allow any fire line to be metered. In 22 towns disastrous fires have occurred owing to the breaking of fire lines cutting off the water supply. At Columbus, Ind., for instance, the falling walls of a building having a 6-in. connection broke this pipe, and the city could furnish no water to fight the fire. Some of the speakers in the discussion thought there should be but one connection for both ordinary and fire supply, while others thought there should be two separate connections, the fire connection valve or gate being sealed.

Mr. Kimball said that at Knoxville, Tenn., his company makes a charge of $3 per 1,000 sq. ft. of floor protected, but makes a rebate on water that is used at meter rates, so that nearly all the company's consumers pay nothing for fire service, as they use enough water to cover the rebate. He did not at all approve of large-sized fire connections to factory buildings. One great trouble is from illegal connections with the mains, the responsibility for which he seemed inclined to put on the employees at the works. He knew of no satisfactory means of finding whether unauthorized connections exist, except by metering the main. After several cases of this kind, the company decided to put meters on all these fire mains, with a sealed by-pass to be opened in case of fire. In one case the insurance company objected, but finally accepted the situation. In another case, however, the owner complained that the insurance company would cancel the insurance if a meter were put on the fire supply, and as the water company insisted on enforcing its rule, the factory company obtained an injunction to prevent its doing so. Mr. Felix thought that in such cases a question to be considered by the court is whether the demands of the insurance companies are reasonable or unreasonable. In one case a cigar factory located on a low-pressure service declared that the insurance company would not insure the plant and demanded that a pipe should be laid from the high-pressure main, although the cost of this would have been very considerable. Mr. Bolling (Richmond, Va.) remarked that giving particular care to provide full fire protection for one plant may be detrimental to the supply of other plants or other parts of the supply system.

A member of the New England Water-Works Association explained that this general question of the metering of fire connections is now being considered by a committee of that association. The committee is composed of five water-works men and two insurance men, the former being in favor of the practice and the latter opposed to it. The President referred to the fact that the discussion appeared to show a very general feeling of the meeting to the effect that all connections should be metered, and on motion of Mr. Bolling (Richmond, Va.) a committee of three was appointed by the President to draft a resolution regarding the metering and control of fire connections. On motion of Mr. J. M. Diven (Elmira, N. Y.), the following resolution in regard to elevator services were adopted:

It is the sense of this convention that all elevator services should be equipped with good positive meters in addition to the regular devices and indicators supplied by the makers.

A CASE OF PIPE CORROSION.

At the morning meeting on June 11 Prof. W. P. Mason, of the Troy Polytechnic Institute, Troy, N. Y., described a curious case of corrosion at Atlantic City, N. J. The pipes were laid 19 years ago, in a black, soft mud which is highly acid and causes severe corrosion of steel, wrought-iron and cast-iron pipe. In the cast-iron mains the corrosion was at all parts of the circumference, sometimes ⅛-in. deep, and in a few spots extending right through the pipe. He exhibited a piece of the pipe where the corrosion had gone through, and the iron appeared to have been replaced by a clay-like substance of very light weight. Examination under the microscope shows particles of metallic iron embedded in the material, while chemical analysis shows it to contain 17% of silica. A member from Jacksonville, Fla., spoke of two suction pipes which were removed and found to have soft spots where the iron could be cut out with a knife. The supply was formerly ground water, but now it is an artesian water impregnated with sulphuretted hydrogen. Wherever brass and iron are in contact on his mains, as at valves, etc., the iron eventually becomes so soft that it can be cut.

MANAGEMENT OF WATER-WORKS.

This was the next paper, and was by Mr. John B. Heim, Superintendent of Water-Works at Madison, Wis. After showing that a plant with the best supply and equipment will not be a success without good management, he showed the importance of a proper decision as to the rates to be charged for selling water, and the very careful investigation necessary for ascertaining what are the proper rates under the special conditions which exist at every city. A sliding scale meter rate he considered decidedly preferable to a flat meter rate. Water waste needs to be carefully looked after, and he has monthly inspections of meters, so as to be better prepared to deal with complaints as to the bills. Valves and fire hydrants are carefully inspected; the latter especially, as their use by the city for sprinkling carts, etc., is liable to result in damage, while the waste of water from the opening soaks the ground and is liable to cause trouble in winter. In the municipal administration of water-works politics is generally a strong influence, and he did not approve the system of administration proposed by the National Municipal League, in which the appointing power lies largely with the Mayor; he thought it the wisest plan to have the water-works under the charge of a board of commissioners.

Mr. Wiles (Delaware, O.) remarked that he puts a gate valve on hydrants used for other than fire purposes. In reply to a question Mr. Heim stated that in Madison the water rates are required to be paid in advance every six months. Bills are rendered against the property owners; if the tenant pays, he is given a receipt, but the owner gets the credit on the books.

HISTORY OF THE WATER-WORKS OF WHITE PLAINS, N. Y.

This paper was printed and distributed, but in the absence of the author, Mr. James M. Farley, of White Plains, the paper was taken as read and accepted for publication in the proceedings. The place is a residential village of about 9,000 inhabitants. In 1886 a contract was made with a private water company organized by Moffett, Hodgkins & Clark, and in 1896 proceedings were begun by the village to acquire the plant, which was accepted by the village in 1897. The paper described the plant and supply system quite fully.

On Thursday morning, June 12, the report of the Secretary and Treasurer was read. This showed the membership to consist of 260 active members, 53 associate members and 7 honorary members, or 320 in all. The association has a credit balance of $2,171.

APPRAISAL AND VALUATION OF WATER-WORKS.

Two papers on this subject were then presented, as follows: "The Arbitration or Appraisal of the Values of Public Utilities," by D. W. Mead, M. Am. Soc. C. E., of Chicago; and "The Financial Question in Water-Works Valuations," by John W. Alvord, M. Am. Soc. C. E., of Chicago. Mr. Mead's paper referred to the general lack of understanding of the nature of appraisal proceedings by officials of companies and municipalities, and proceeded to describe the organization and duties of appraisal boards. The basis of valuation will include one or more of the following: (1) Original cost of works; (2) cost of reproduction of works; (3) depreciation; (4) operation or "going" value; (5) valuation of franchise, rights, privileges or concessions, and of business acquired or prospective; (6) valuation for salvage. As to expert assistants in the preparation of the case, the following remarks were made:

Both the owner and the municipality will often greatly advance their interests and cheapen the cost of appraisal if they will employ experts to work up the features of their case and to represent them before the board. Experts should be employed for this purpose who are thoroughly familiar with the usual character and nature of the proceedings involved. Such an expert can examine the property, plant and records, interview officials and gather in a brief time and from a mass of material (much of which may be undesirable and incompetent) evidence which it might take a board days to sift out, or which such a board might not and often would not discover or ascertain at all.

Mr. Alvord's paper discussed the financial side of the system of valuation, under the heads of (1) business value, (2) franchise value and (3) fair return. He laid particular stress upon the fact that the duties of appraiser are those of a judge rather than of an attorney for either side of the case, but thought that engineers are usually not well informed upon the financial aspects of such cases.

It often happens that water-works men and hydraulic engineers, skilled in the construction and designing of water plants, are selected as arbitrators under some special clause of the franchise, or are requested to present the claims of one or the other of the interested parties. Such men are unquestionably well qualified to judge of the physical value and depreciation of the plant which it is desired to purchase, but it is observable that not every engineer or water-works man charged with such responsibilities has clear and distinct notions of the financial questions involved.

In the discussion Mr. Mead referred to correct and incorrect methods of arriving at the depreciation, and explained that maintenance cannot be made to provide for depreciation. Mr. Geo. H. Benzenberg, M. Am. Soc. C.

E. (Milwaukee, Wis.), remarked that no general figures can be arrived at for depreciation, but in each and every case the local conditions must be taken into account, and then a sinking fund established which at the end of the term of years taken as the life of the plant will provide for the renewal of the plant. The term franchise is often misunderstood, he thought. It is not a license to do business, as a water company distributing water in barrels, bottles, etc., needs no franchise; but it is a grant of the privileges to use the public streets and highways for the company's business. He thought there was much more trouble from tuberculation of pipes in the Eastern than in the Western cities. Mr. Benzenberg laid special emphasis upon the importance of greater care in the coating of water pipe, in view of the large proportion of the investment which is represented by the pipe, and in view also of the importance of keeping the pipe in good condition. He advocated cleaning the pipe by the sand blast and then giving it two immersions in the bath. This would not materially increase the cost of the pipe. In one case where this treatment was specified the increase was only $1 per ton. He suggested the future use of porcelain-lined pipe.

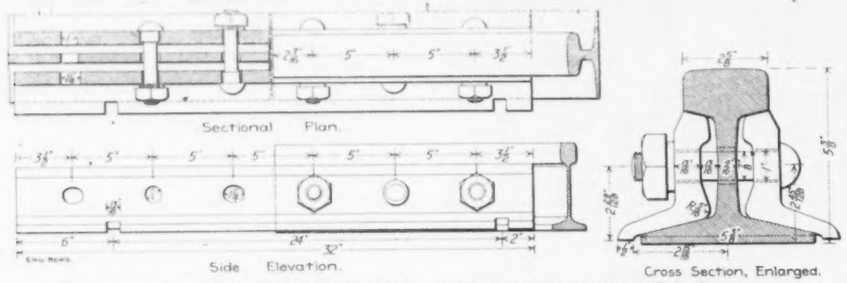


FIG. 1. OLD 6-BOLT ANGLE-BAR JOINT; PITTSBURG & LAKE ERIE R. R.

THE DISTRIBUTION OF FIRE HYDRANTS.

A short paper on this subject was then read by Mr. S. A. Charles, Superintendent of Water-Works at Lexington, Ky., in which he gave the results of experiments made to convince the fire department of the loss of pressure by friction in long lines of 2½-in. hose. His results agreed closely with those obtained by Mr. Freeman, although his tests were made with less care. With a gage at the hydrant registering uniformly 100 lbs., another gage at the base of a play-pipe at the end of different lengths of hose showed pressures as follows:

Distance	Pressure	Distance	Pressure	Distance	Pressure,
ft.	lbs.	ft.	lbs.	ft.	lbs.
50	87	400	55.7	800	38.1
100	80	500	50	900	34.8
200	69.2	600	45.5	1,000	30
300	61.2	700	41.5	1,500	22.4

This paper will be given more fully in a later issue.

The members did not appear to be very eager for the evening session, and it was nearly 9 p. m. before the President could call the meeting to order. The Secretary read the report of the Executive Committee, which led to some discussion on the arrangements for the publication of papers and discussions.

SOME SMALL WATER-WORKS PUMPING INSTALLATIONS.

Mr. D. W. Mead, M. Am. Soc. C. E., then read the paper set for the evening meeting, which was illustrated by stereopticon views. The plants described were selected as illustrating special arrangements designed to meet special local conditions. At West Dundee and Algonquin, Ill., water is pumped by water rams under 55 ft. and 23 ft. head, the former making 12 to 14 strokes per minute, and the shock or water-hammer being reduced by a check valve of large area. At Deer Park, Ill., a ram is fitted on an artesian well. Dundee, Ill., has a gasoline engine pumping plant for fire service. At several places water is stored in tanks upon the ground, which are much cheaper than standpipes or water towers, pressure being obtained by compressed air. This pressure is about 25 lbs. when the tanks are almost empty, or 65 lbs. when they are half full. At Winchester, Ind., an engine operated by natural gas drives the pumps and electric light generators. As the engine cannot be operated at low speed, a by-pass circulating system is put in service when pumping is not required, a check valve retaining the pressure in the mains. At De Kalb, Ill., the force pumps are driven by an electric motor supplied with current from a power station ½ mile distant. At New Albany, Ind., deep wells open into a pump shaft at the bottom of which are placed three horizontal centrifugal pumps (one above the other) driven by an electric motor. A similar plant, but with steam engine and rope drive, is projected at Fort Worth, Tex. The pumping plant at Rockford, Ill. (Eng. News, July 13, 1899), with steam engines and rope drive to vertical centrifugal pumps placed in a pump shaft, was also described.

PREPARATION OF WATER FOR PURIFICATION.

This was a brief paper by Mr. J. P. A. Maignen, Assoc. Am. Soc. C. E., of Philadelphia, describing a preliminary system of sedimentation which consists in passing the water through a series of baffle plates, between which particles of solid matter will be deposited.

Mr. Charles mentioned a plant for purifying water of very bad quality at Lexington, Ky. The amount of coagulant used is only ⅛ grain per gallon, but the water is aerated by spraying it upon a filter bed.

APPARENT ESSENTIALS OF DRINKING WATER.

At the meeting on Friday morning, June 13, Mr. C. Monjeau (Middletown, O.) read a paper in which he declared all methods of artificial purification to be based on incorrect principles, and advocated what he termed a natural purification of the water by the soil.

THE IRON PROCESS IN FILTRATION.

This paper, by Mr. R. E. Milligan (Chicago) described the iron process as now used at Quincy, Ill., and Lorain, O., where formerly alum was used as the precipitant. Mr. Maignen objected to the use of iron, on account of certain chemical effects, but a member from Quincy stated that the water is very soft and very satisfactory. Since the use of the iron process, the boiler scale formed when alum was used has come away and little or no new scale has formed. The engineman in charge of the pumps attends to the plant, so that there is no extra labor charge.

The two remaining papers were read by title, as follows: "Personal Experience in the Management of Water-Works," by L. N. Case, of Duluth, Minn.; "Fire Protection," by Charles A. Hague, of New York, N. Y.

COMMITTEES.

The Committee on Publication presented, through Mr M. R. Sherrerd (Newark, N. J.), a report recommending that papers should be in the hands of the Secretary 20 days before the meeting, that all papers should be submitted to the Publication Committee for acceptance or rejection, and that the stenographer's notes of discussion should not be given out until submitted to the speakers for correction. These recommendations, with some modifications, were embodied by the Executive Committee in their changes of the by-laws. The Committee on Electrolysis had no report, Mr. D. H. Maury, M. Am. Soc. C. E. (Peoria, Ill.), explaining that the committee having presented a report last year, considered its work ended. It was voted, however, to continue this committee as one of the standing committees. A brief report from Mr. J. J. R. Croes, M. Am. Soc. C. E., of the Committee on Uniform Specifications for Cast Iron Pipe, recommended that the association should take up for discussion the specifications issued by the New England Water-Works Association. It was voted that these specifications should be published in the proceedings and made a special subject for discussion at the next annual meeting. The Committee on the Control of Fire Service made a brief report, stating that the objection of insurance companies to having meters put on fire connections is natural but not well founded. It recommended that every application for fire connections for factory plants, etc., should be accompanied by a plan and a statement as to whether the water would be used for other than fire purposes. All cost, including that of the meter, to be borne by the owner or applicant. The size of the connection to be determined by the engineer or superintendent, and ... to be taken to prevent surreptitious use of water. Committee on Memorials presented resolutions con... the deaths of Messrs. Peter Milne, A. S. Leeds, ... Laing and Wm. Himrod. The Committee on Resol... presented the usual resolutions of thanks to the ... committee, etc., for the entertainments provided.

The entertainments included a reception at the ... torium, two drives through the park systems of the ... a steamer trip to the new Carter Harrison Crib, ... another steamer trip on the Drainage Canal. There ... only a limited display of exhibits, and notes of these ... given elsewhere.

ELECTION OF OFFICERS.

The association still retains the old system of ma... personal nominations during the meeting, although ... system is not suited to so large an association, and ... Wednesday morning 1½ hours were spent in nomina... and electing officers. This was not only a waste of ti... but left the actual election in the hands of a compa... tively small number, as the proceedings were so te... that many members left the room. As often happ... members proposed different ways of conducting the el... tion in order to save time, and one new method ... adopted, with the result that the proceedings became ... tangled that it was necessary to rescind the resolu... adopting this method, cancel previous nominations and start again in the usual way.

The following officers were elected: President, C. H. Campbell, Charlotte, N. C.; Vice-Presidents, L. N. Case, Duluth, Minn.; M. R. Sherrerd, Newark, N. J.; C. E. Rowe, Dayton, O.; B. C. Atkins, St. Louis, Mo.; C. F. Frailey, Lancaster, Pa.; Secretary and Treasurer, J. ... Diven, Elmira, N. Y. It was voted to hold the next an... nual meeting at Detroit, Mich.

RAIL JOINTS ON THE PITTSBURG & LAKE ERIE R. R.

Following the general tendency towards the use of short splice bars, Mr. J. A. Atwood, M. Am. Soc. C. E., Chief Engineer of the Pittsburg & Lake Erie R. R., has recently reduced the length of the standard angle bar of that road from 32 to 26 ins. The old 32-in., 90-lb. splice bar, and the new 26-in., 90-lb. and 80-lb. splice bars are illustrated herewith. The number of bolts has been reduced from six to four, and the spacing of bolts has been changed as shown. The main line is laid with 90-lb. rails of the Am. Soc. C. E. section, and all new yards are being built with 80-lb. rail.

In order to obtain uniformity as far as possible in the details of track, both 80-lb. and 90-lb. rails and splice bars are drilled and punched and slotted alike. The size and length of track bolts for both joints are identical.

All nuts have square heads with 1 7/16-in. sides. The slots in the angle bars for the track spikes have been arranged with reference to a standard tie-plate, and so spaced as to permit the driving of spikes without interference by the bolt.

The drilling of the rails and punching of the angle bars is alternately round and oval, which is a feature of joints which produces excellent results. In changing the spacing of track bolts the two interior bolts were placed 4 ins. apart, which was decided to be the closest allowable spacing. The object in adopting a spacing 7 ins., 4 ins., 7 ins., was to obtain the strongest possible four-bolt joint. The diameter of both 80-lb. and 90-lb. track bolts is ⅞-in.

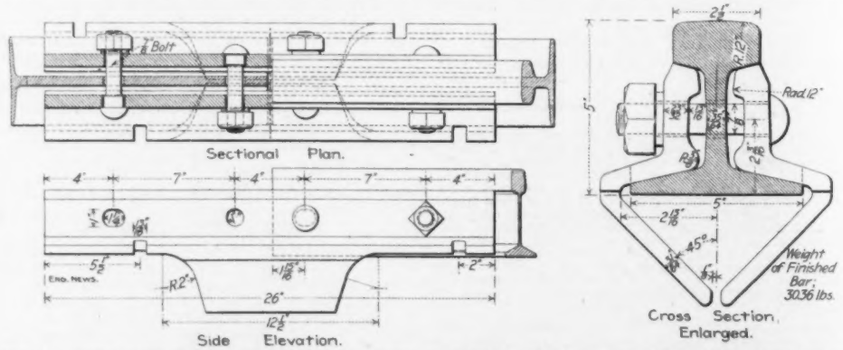


FIG. 2. NEW "100 PER CENT." 4-BOLT JOINT FOR 80-LB. RAIL; PITTSBURG & LAKE ERIE R. R.

There are on this railway at the present time several stretches of track laid with ordinary angle bars, and with the Bonzano, Continuous and 100% rail joints, all of which have splice bars specially formed.

ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS.

The fifth annual meeting of the American Section of the International Association for Testing Materials was held at Atlantic City, N. J., on June 12, 13 and 14, during which time the members present held five sessions. There were about 75 members present. Practically all of the time of the first session was taken up in transacting society business, and the remaining sessions were devoted respectively to the consideration of specifications, steel, cement and cast iron.

FIRST SESSION.

After some routine business, the President, Prof. Henry M. Howe, formally introduced the work of the convention by an address, in which he reviewed briefly the objects of the society and the steps which had been taken to place it on a definite basis of operation. The most important of these steps were reviewed briefly as follows:

As is explained at greater length in my report on the Budapesth Congress, the President and Council of the International Association seemed unalterably opposed to the formation of national sections, and insistent that national or other local organizations of members of the International Association should be, not sections, but independent organizations, of which preferably every member should be also a member of the International Association. In asking for the recognition of the American Section, we asked them for a measure of independence. They in effect replied, make your independence complete.

That our independence should be complete seems very desirable on account of the extreme divergence between the policy of the majority of the European members of the International Association and our own policy. They regard methods of testing as the subject of paramount importance, and the erection of standard reception specifications as wholly secondary; indeed, a very large fraction of our European colleagues seem strongly opposed to even raising the question of standard specifications. We regard the question of standard specifications as of paramount importance, as indeed an important world-question, and we regard the question of methods of testing as of a much lower degree of importance. With such a divergence of views, serious conflicts should be apprehended if we owed to the parent society the allegiance of even a limited suzerainty. Your Executive Committee therefore has adopted and will recommend to you the plan of changing our condition from that of a section of the International Association to that of a quasi-independent though very closely affiliated society, of which every member must necessarily be a member of the International Association, though members of that association resident in America need not, if we be abhorent to them, join our society. Few such will probably be found.

This, then, is our record of things done or begun:

(1) Harmony with the parent society.

(2) The establishment of a permanent working secretaryship.

(3) An appeal to the industries which we serve for the sinews of war to make our service effective.

(4) The change of state to that of an independent affiliated society.

Following the address of the President came the reports of the Secretary and Treasurer, which showed that there had been a small growth in membership during the year and that the expenditures had exceeded by a nominal sum the receipts. The report of the Executive Committee regarding the change in the name and status of the society which had been mentioned by the President was then presented. This report showed that a charter had been secured from the State of Pennsylvania incorporating the American Society for Testing Materials, and that by-laws had been drawn in accordance with this charter. The members were asked to consider the charter and by-laws and vote their acceptance or rejection. After some modifications of and additions to the by-laws as drafted, they were adopted, as was also the act of incorporation. It was then voted to elect all members of the old society to membership in the new society, and also to assume the assets and liabilities of the old society. These actions occupied the entire time of the first session.

SECOND SESSION.

The first business of the second session was the Report of Committee No. 1, which was read by Mr. Wm. R. Webster. The report stated that the committee had done but little work during the year, but that the specifications which were the result of its previous labors had been discussed and were under investigation by a number of the other societies. The report also pointed out that the specifications for steel rails adopted by the American Engineering and Maintenance-of-Way Association at its annual meeting in Chicago on March 18-20, 1902, made a number of modifications in the standard specifications for steel rails adopted by the American Society for Testing Materials, and that these modifications were presented for discussion.

The two changes which called out the most discussion were that which required a drop test on a piece of rail from every heat instead of on one rail in every five heats, and that relating to heat treatment in rolling, which was specified as follows:

HEAT TREATMENT.—The number of passes and speed of train shall be so regulated that on leaving the rolls at the final pass the temperature of the rail will not exceed that which requires a shrinkage allowance at the hot saws of — inches for 85-lb. and — inches for 100-lb. rails, and no artificial means of cooling the rails shall be used between the finishing pass and the hot saws.

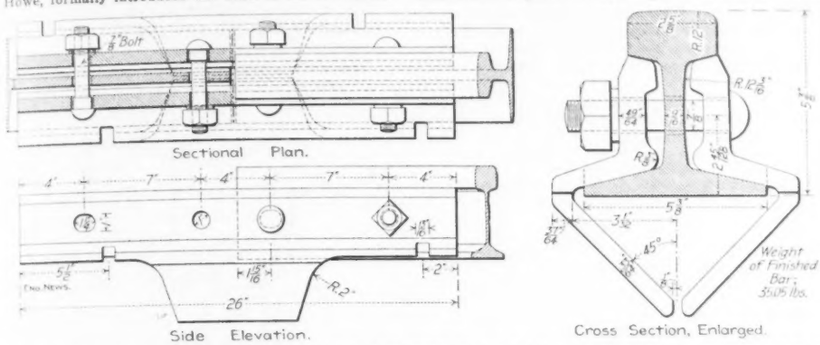


FIG. 3. NEW "100 PER CENT." 4-BOLT JOINT FOR 90-LB. RAIL; PITTSBURG & LAKE ERIE R. R.

The discussion developed a strong opposition to both of these changes. Respecting the proposal to test every heat, it was pointed out that the specifications were intended to represent standard practice, and that at present the standard practice was to test one rail in five heats; that in modern rail mill practice the heats were so frequent (one in every five or six minutes) that to drop test a rail from each heat was practically impossible, unless a number of testing appliances were installed; that the chemical composition in modern works run so evenly from heat to heat as to make such frequent testing needless, and that as a matter of fact, if a certain knowledge of the rail was to be had, it would be necessary to test both ends of every bloom; this was impossible, since all that was necessary was to keep a general check on the material, which could be done by making a drop test for every five heats. It was finally voted to refer the matter back to Committee No. 1, with the remark that it was the general sense of the meeting that one test in every five heats was ample for the purpose sought.

The addition of the clause specifying a minimum shrinkage as a regulation to the finishing test of the rail was also vigorously opposed. The arguments against it were: That there were not sufficient data available upon which to base a conclusion as to what the shrinkage should be in the first place, and, in the second place, that it was by no means certain that shrinkage was a reliable measure of temperature. It was voted to refer the subject back to the committee for investigation.

The next business was the topical discussion of the question, "Is It Desirable to Specify a Single Grade of Open-Hearth Structural Steel for Bridges of Ordinary Span?" The report of this discussion, which proved a very interesting one, we postpone to our next issue.

THIRD SESSION.

At the third session of the convention the following papers were presented: "Finishing Temperature and Structure of Steel Rails," by Albert Sauveur; "Rail Temperatures," by S. S. Martin, and "The Ethics of Testing," by P. Kreuzpointner. The paper by Mr. Sauveur alone received discussion. After stating briefly the phenomena of crystallization as effected by slow cooling and by rapid cooling and by working, the author criticised the Kennedy-Morrison rail finishing process in some detail, as follows:

THE KENNEDY-MORRISON RAIL FINISHING PROCESS.—The suddenly renewed interest in the subject of proper finishing temperature for steel rails, just alluded to, led the Carnegie Steel Co. to a notable departure at their Edgar Thompson plant, from the ordinary mode of proceeding. This move on their part was given much publicity and has attracted the attention of all rail consumers. Stated briefly, the modification which they have introduced in the rolling of steel rails consists in holding the rails on a cooling table a few minutes before subjecting them to the last pass. It is argued that by so doing the rail is finished at a lower temperature, which is the desideratum aimed at.

Let us look critically into this new departure in rail rolling. The rail when it reaches the cooling table introduced before the final pass is at a high, or relatively high, temperature, and is then allowed to cool until a certain lower temperature is attained. During this undisturbed cooling the metal evidently crystallizes, and the rail must necessarily enter the finishing roll in a crystalline condition, which will be the more pronounced the higher the temperature of the rail when it reached the cooling table and the slower and more prolonged the subsequent undisturbed cooling. It also seems as if the single pass to which the metal is subjected after this crystallizing period cannot be sufficient to break up the crystallization just created. On theoretical grounds, therefore, if a material gain results from this method of proceeding, I do not see how it can be accounted for. Let us remember that any undisturbed cooling above the critical temperature constitutes a crystallizing period. By partially cooling the rail before the final pass, we shorten the crystallizing range after the rail has left the finishing roll, but we create a crystallizing period just before the final pass, which is exactly equal in length to the diminution of the final undisturbed cooling. We do not, by so doing, decrease the total crystallizing range, which alone governs the size of the final crystals; we merely divide it, causing a part of it to be located immediately before the final pass and the balance immediately after, so that a rail treated by this process has passed through a crystallizing period of exactly the same length.

The only beneficial effect, therefore, that can be claimed for this process is that it breaks up the crystals produced just before the last pass, resulting in a finer structure rail. If we consider that the reduction produced by the last pass is about 5%, it seems hardly conceivable that so slight an amount of work could be effective in breaking a pre-existing coarse structure.

Similar criticisms of the value of the Kennedy-Morrison process have been published by Mr. S. S. Martin, of the Maryland Steel Co., who contends, apparently on good ground, that any undisturbed cooling introduced in the process of rolling, in order to be effective in producing a finer grained rail, must take place at an early period, because then the considerable reduction, i. e., the great amount of work to which the rail is subsequently subjected, will break up the crystals formed during that undisturbed cooling. It has also been argued, and rightly, I think, that those mills which do not reheat their blooms produce finer grained rails, for the simple reason that they finish their rails at a lower temperature.

To sum up, in order to confer a fine-grained structure upon steel rails, three courses seem to be opened:

(1) To shorten the crystallizing period, i. e., the time during which the rail is allowed to cool undisturbedly above the critical temperature (say, about 700° C.). In other words, the rail should be finished sufficiently cooled, and the finishing temperature will, of course, depend in turn upon the temperature of the ingot when rolling begins and upon the speed of the operations. The main objection to starting and carrying the rolling at a relatively low temperature is that it throws more work upon the rolls. The objection to a slow rolling speed and handling of the material is that it decreases the output of the mill. Both objections imply an increase in the cost of the rail.

(2) To cause a part of the crystallizing period to occur previous to the final pass, i. e., to allow the rail to cool undisturbedly at some stage of the operations, and for a short time, before completing the rolling. This cooling, in order to be effective, should occur at a sufficiently early stage of the rolling, in order that the resulting crystallization may be broken up through a sufficient amount of subsequent work and reduction. Such results would be obtained by placing the cooling table at the shears. The objection to this course is that the shaping of this cooler bloom into rails would require greater mechanical effort, and therefore increase the cost of production.

(3) To finish the rail at the temperature most desirable for easiness and speed of manipulation in rolling and then to reheat it to a temperature slightly above the critical temperature, a treatment which would result in the breaking up of the pre-existing coarse structure, replacing it by a much finer one. This course would undoubtedly be the most effective of the three, as it would not only impart a fine structure to the rail, but also a uniform structure to all its parts, while a rail not so treated must necessarily be coarser in the central parts than nearer the cooling surfaces, owing to the higher temperature of the center when the rail leaves the finishing rolls and to its slower subsequent cooling. The cost of such reheating treatment would undoubtedly be very great and, possibly, prohibitive.

The discussion on this paper was opened by Mr. P. H. Dudley in a written communication, from which we make the following extracts:

Professor Sauveur, by treating the subject as a general proposition, without mentioning any of the relations a rail sustains by its section and stiffness to railway service and interests, perhaps condenses his paper too much, for it will be read rather in an educational than a technical sense by a majority of readers. Many will infer that colder rolling is the only important requisite now required to make rails which will meet the demands of present service, reducing the loss of metal by wear to as slow a rate as was the case on the early Bessemer steel rails of two decades ago under the lighter wheel loads. This would be a return to the practice which then prevailed with the limited output, and a price of rails of three to four times the present cost. Besides a return to the slower and consequently colder rolling from the small ingots of the early Bessemer steel rails which replaced iron, a sound ingot is needed of a grade of steel which will produce the essential physical properties for the rails as girders and also insure a slow rate of wear.

It should not be forgotten that while we are all familiar with the rapid doubling and trebling of the wheel loads in the past decade, the strains in the rails as girders are principally met by elasticity of length, while the increased intensities of the wheel pressures per unit of contact between the wheel treads and the rail heads are sustained more by the elasticity of volume, which is quickly reduced by the slightest unsoundness of the metal in the surface of the rail head. Therefore, to have the most benefit from colder rolling or heat treatment, the metal must be sound and homogeneous.

The evolution of the present "up-to-date steel mill" has been more in the direction of increasing the "output" and decreasing the cost of the production than of any intention of decreasing the quality of the finished rails. The mechanical conditions for an increased output have received most of the consideration. It was not anticipated from a metallurgical standpoint—the latter not being so well understood—that there would be a decided reduction in the quality of the product from the same composition as was used for the earlier sections. These had more work, in fact, by eliminating the essential time element for crystallization in the slower and colder rolling. Now that a large product can be secured, the question of quality for present service is being considered more generally.

There does not seem to be any reason why the construction of a rail mill is not possible which will permit not only much colder rolling and finishing temperatures than are now general, without restriction of the "output," but turn out a more uniform and better finished

section than is now produced. The standards of smoothness of track are now much higher than a decade ago on all of the important trunk lines, and they have not reached their limit. The smoothness of the surface of the rails rather than its wear now determines when they must be replaced.

In the first paragraph and the first sentence of the second of Professor Sauveur's paper he states, as he says, well known facts. The statements are generally true as applied to blooms or material which has been rolled from the ingot, but do not cover all the work to be done when rolling rails direct from the ingots or to blooms.

The fluid steel of about 1,450° C. is tapped from the teeming ladle into the mold, the steel on congealing forms a decided columnar structure interiorly from the sides of the iron molds of 1½ ins. in thickness, the interior mass crystallizing in the usual granular or polyhedral forms. The ingots, after cooling 15 to 20 minutes, are set sufficiently to be stripped, and are then placed in furnaces or soaking pits until the heat of the interior and exterior portions of the ingot is sufficiently equalized to about 1,100° C. or 1,150° C. for blooming. The work of the blooming passes breaks up the coarse columnar structure, though rarely without several skin cracks occurring, which, though not completely, roll out partially in the roughing and finishing passes for the rails. Some "seconds" are produced, the percentage being high when exceeding 5 or 6%.

It requires close attention to the composition and manufacture to produce an ingot with a columnar structure that will withstand the subsequent heating and blooming without cracking. "Cobbles" are not infrequent. If the rolling is direct from the ingot to the finished rail, then the work of the passes must break up not only the ingot structure, which seems to be done before or during the "dummy" pass, but prevent the building up of a coarse structure until the work ceases. This should be near or slightly below the critical temperature for the given composition.

Rolling or forging not only can break up a structure during "hot work," but check a large crystallization to the critical temperature for the steel.

"Hot work" influence the final texture of steel by breaking up the ingot or bloom structure, as the case may be, reducing the steel to a plastic or possibly a porcelanic condition, and by eliminating the essential time element for the crystalline forces to rearrange the combinations retards crystallization from a higher to the critical temperature for the composition.

This important principle, so clearly set forth in other words in Professor Sauveur's paper, is the keynote of practice to be observed to improve the quality of steel rails during the period of proper hot work. It can be so well applied in practice as not to restrict the output. Rolling may be continued some 50° or 60° C. below the critical temperature without sufficient loss of ductility to be of moment. "Blue working" is not advisable, though below this temperature the steel again increases in tensile strength, then reducing slightly as it reaches 30° C.

Some of the early foreign Bessemer steel rails were rolled until the critical temperature in the head was passed, while one firm toughened their rails. In regard to ductility, I place more restriction upon it than Professor Sauveur does in his paper. In rails I insist upon high elastic limits in the metal and then the requisite ductility for safety and good wear of the rail heads.

Rails in the tracks of steam railways to carry the moving wheel loads must perform the functions of continuous girders, and we are limited as to the amount of ductility we may give the metal for rails. The rails must be elastic and should have high elastic limits, 55,000 to 60,000 lbs., and then have the requisite ductility and fine-grained structure in the metal for wear. Unit fiber stresses in the base of rails under high speed trains, even in 80-lb. rails of 45,000 lbs. in tension, are not uncommon.

It is a fact now known, but not generally understood, that the stresses in the rails increase decidedly under the large expenditures of tractive power, beside that due to the weight and speed of the locomotive. With the increased service which has followed the introduction of the heavier and stiffer rails, there has been a legitimate increased wear of the head, while there has been some increased wear due to the quality of the product. The increased axle and train loads have resulted in a decrease of operating and maintenance expenses, so that from the financial standpoint it is found desirable to use the stiffer and heavier rails. The demand for such rails at the present time (1902) exceeds the output of the mills, and any manipulation of the process of manufacture which will limit the output is not likely to receive much consideration. There is no reason, however, why the output need be limited to insure much colder rolling or the manufacture of a fine grained rail.

Rails rolled direct from the ingot have a finer texture, as would be expected, than those from the same composition rolled from re-heated blooms. The shrinkage allowances now prescribed for 80 and 100-lb. rails are yet in excess of the allowance for the former lighter rails, and some reduction in the future may be expected.

FOURTH SESSION.

The papers and discussions at the fourth session of the convention all related to cements and concretes. The discussion was opened by Mr. R. W. Lesley, who took for his theme the correlation of cement specifications. Mr. Lesley pointed out that there was to the manufacturer a most distressing lack of uniformity in the requirements which engineers specified that cement must satisfy. The trouble was not so much that any individual specification was a bad one or unreasonable in its requirements as it was that the requirements of no two specifications agreed. In view of this, it seemed desirable that some effort should be made to eliminate these differences by adopting a standard uniform specification, and the speaker urged that the society should take steps to promote this desired object. Following Mr. Lesley a paper entitled "The Advantages of Uniformity in Methods of Testing and Specifications," by Mr. G. S. Webster, was read, and this was followed by a paper on "The Chemical Analysis of Cement; Its Possibilities and Limitations," by Mr. R. K. Meade. In a paper on "Cement Testing in Municipal Laboratories," Mr. R. L. Humphrey gave an interesting historical account of the meagre development of municipal cement laboratories in the United States, compared them with some of the more notable European establishments of a similar character, and presented a brief argument in favor of their more extensive adoption and better equipment. A paper entitled "Tests of Reinforced Concrete Beams" was then read by Prof. W. K. Hatt, which we shall reprint in a future issue. The discussion on these papers was all of a general character and brought out very little additional information.

FIFTH SESSION.

The fifth and last session of the convention was given up to papers and discussion on cast iron. For the most part the papers were of special rather than of general interest, and they are given by title only, as follows: "Notes on the Constitution of Cast Iron," by Henry M. Howe; "Effect of Variations in the Constituents of Cast Iron," by W. G. Scott; "Present Status of Testing Cast Iron," by R. G. Moldenke; "The Need of Foundry Experience for the Proper Inspection and Testing of Cast Iron," by Thomas D. West; "A Quick Foundry Contraction Test for Metals," by Asa W. Whitney; "High Strength of White Iron Castings as Influenced by Heat Treatment," by A. E. Outerbridge; "Digest of Current Specifications for Cast Iron Pipe," by Walter Wood.

ELECTION OF OFFICERS.

The following officers were elected to serve the society during the ensuing year: President, Dr. C. B. Dudley; Vice-President, Mr. R. W. Lesley; Secretary-Treasurer, Prof. Edgar Marburg; Member Executive Committee, John McCloud.

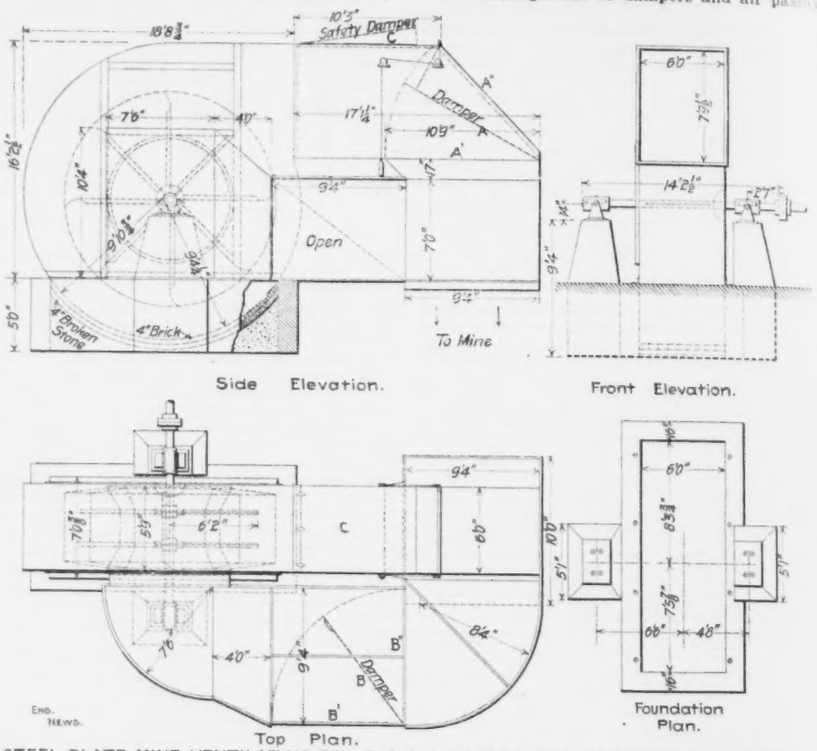
STEEL PLATE FAN FOR MINE VENTILATION; MODOC COAL CO., GLOUSTER, O.

In discussing the subject of tunnel ventilation some months ago, we stated that engineers in railway practice were too little acquainted with the progress made in the movement of air in large quantities for mine ventilation purposes, and that if the same degree of intelligence and enterprise had been devoted to tunnel ventilation that has been given to the vastly more difficult matter of mine ventilation, the traveling public would not now be in the dark ages (to speak figuratively and in some cases literally) in the matter of tunnel operation.

With this as a text, we commend to the attention of our readers the large steel plate fan shown in the accompanying drawings. It was built by the Buffalo Forge Co., of Buffalo, N. Y., for ventilating a coal mine belonging to the Modoc Coal & Mining Co., of Glouster, O., the engineer and contractor for the installation being Mr. Cass Harkins, 1001 Hayden Building, 16 E. Broad St., Columbus, O. The fan housing is 250 ins. in diameter and 72 ins. in width, with sides built of heavy sheet steel braced with angle irons. The blast wheel has the tips of its vanes slightly curved backward. It is built up of steel plate supported by two spiders of wrought-iron tees, springing from cast-iron hubs and the whole stiffened and braced by conical side plates.

The blast wheel is carried on a 6-in. shaft having a span of 10 ft. 8 ins. between centers of bearings. To guard against hot bearings due to deflection of the shaft, these bearings are hung on trunnions. This type of bearing is a special construction of the Buffalo Forge Co. The bearings are supported on masonry pedestals, are oiled by endless chains, and there is provision for water cooling, so that the fan may never have to stop on account of a hot bearing.

The arrangement of dampers and air passages



STEEL PLATE MINE VENTILATING FAN FOR THE MODOC COAL & MINING CO., GLOUSTER, OHIO.

Cass Harkins, Columbus, O., Engineer. Buffalo Forge Co., Buffalo, N. Y., Builders.

is an unusual one, it being so designed that the fan can be used for either the plenum or vacuum system of ventilation. That is to say, it can either blow the air into or exhaust it from the vertical mine shaft located at the outlet end of the fan. The passage to the inlet is controlled by the two-way damper A, that from the outlet by the two-way damper B. Under ordinary conditions it is desired to exhaust the air from the mine; the inlet damper A will then occupy the position A, while the outlet damper B will be in the position B. When, in case of accident, or for other reasons, it is desired to blow into the mine, these dampers occupy the positions A" and B", respectively. A weighted door opening outward is placed in the connections over the shaft, as shown at C, to prevent injury to the apparatus in case of an explosion in the mine. The opening to the mine shaft is 93 sq. ft. in area.

Working with a free delivery, this fan will discharge 1,600 cu. ft. of air per revolution. Under the conditions of actual operation, it is intended to work against a pressure of about 2 ins. of water, and against that head it is designed to deliver 125,000 cu. ft. of air per minute at a speed of 150 revolutions. The fan is driven by a single-cylinder direct-connected 12 × 20-in. engine developing about 80 HP. at 150 revolutions with 95 lbs. of steam.

We are informed that a similar plant to the above is being built by the same contractors for the New England Mining Co., at Sayre, O.